Practical Manual of the E-6B Computer

ALLAN C. ZWENG

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PRACTICAL MANUAL OF E-6B COMPUTER

by

ELMER F. DEGON

ALLAN C. ZWENG

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PREFACE

The Dalton E-6B type computer was developed by the late Lt. Philip Dalton, U.S.N.R. At the present time this computer is standard with the U.S. Army Air Forces and is probably the most widely used of the various types accepted by pilots and navigators.

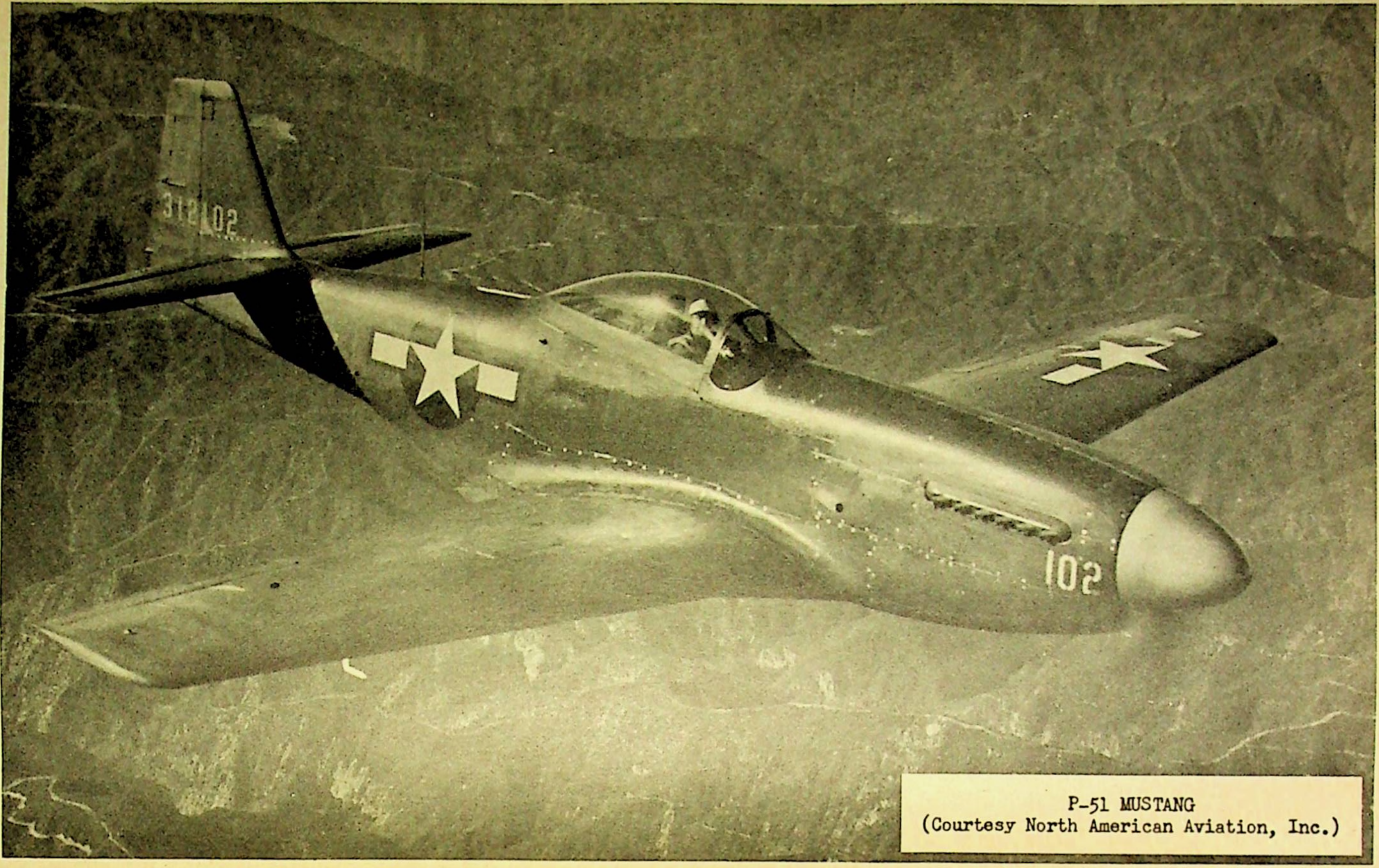
It is not the purpose of this manual to explain the dead reckoning problem procedure, but to apply the E-6B computer to the many major and minor problems of navigation as they concern the airman. For the principles of the vector problem and the slide rule solution of mathematics, any good, sound text is recommended. The authors suggest Weems' "Air Navigation," Gold Medal edition; "Air Transport Navigation," by Redpath and Coburn; or "Army Technical Manual 1-205."

The student should study this instruction manual faithfully and apply soundly his previous knowledge of the problem type to the simpler computer method. All problems in the manual should be worked and checked with the answers. The first problems which include distance conversions may seem simple but will give needed practice in reading the semi-difficult slide rule scales. Accuracy must be attained before speed.

The different problem methods are amply illustrated in an original step method so that with a fair amount of application the airman can easily learn to be fast and accurate with both the vector and the slide rule problems.

Elmer F. Degon
Allan C. Zweng

Studio City, California
June, 1944



P-51 MUSTANG
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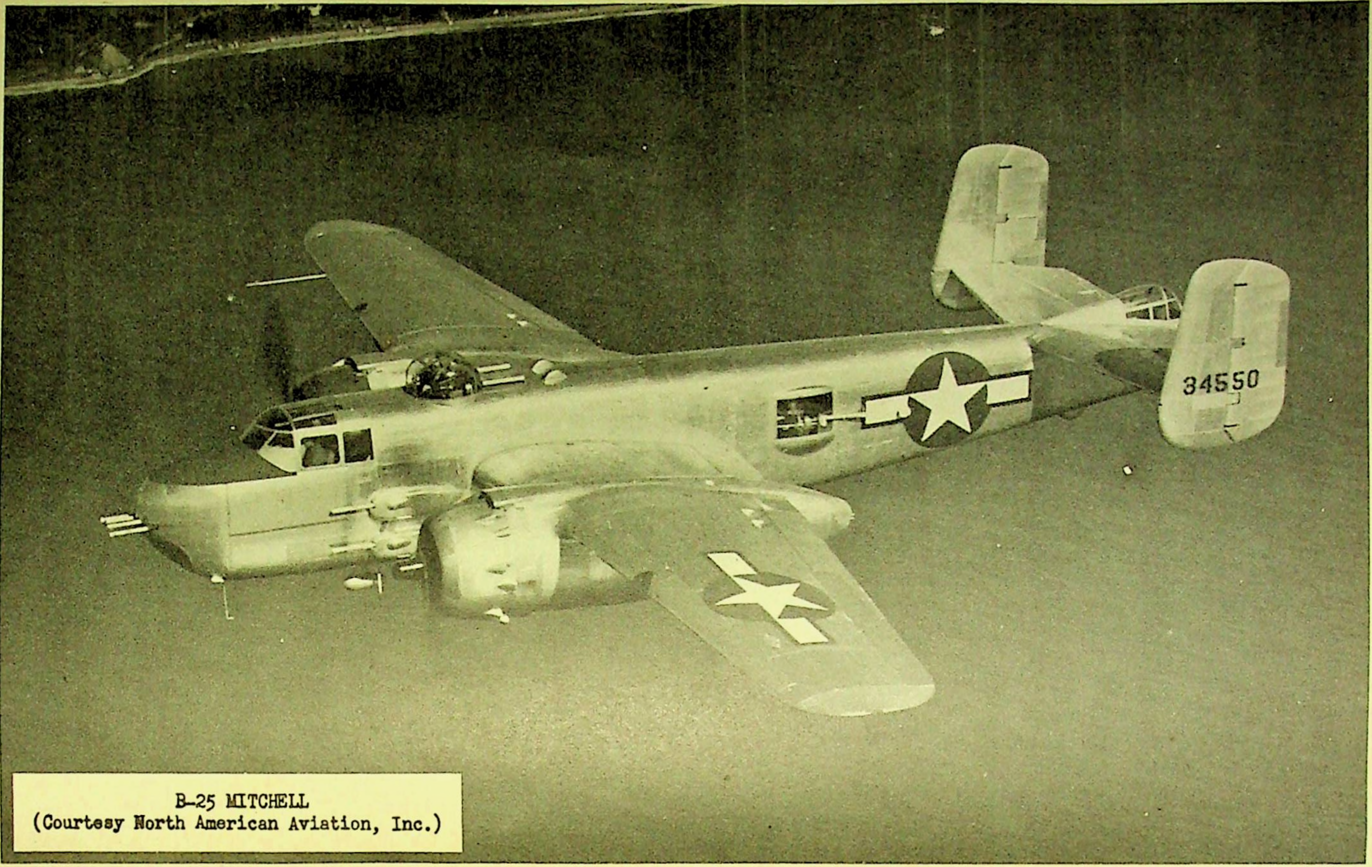

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EXPLANATION OF THE CIRCULAR SLIDE RULE

The Dalton dead reckoning computer, Type E-6B, was designed to simplify solution of the various vector problems encountered in dead reckoning navigation and to eliminate, so far as possible, the mental calculations usually involved.

The face of the instrument embodies a transparent plotting disk mounted in a rotatable compass rose, the center marked by a small black circle called the "grommet." A sliding grid is fitted to move beneath the transparent plotting disk. This grid is actually a section of a 360 degree plotting circle, the center or zero point not being shown since speed ranges of 0 to 30 will seldom if ever be used. The curves on the grid represent the concentric circles around this center, distance from the center being indicated at ten-mile intervals by the figures on the vertical center line. The lighter, intermediate curves are spaced at two-mile intervals.

The radiating straight lines indicate direction from the center of the circle and are used to set up courses and headings and to determine drift angle.

Above the rotatable compass rose is a scale with a true index marking at the center. The scale runs from 0 to 45 degrees to the left and right of the true index. This scale is used for applying east and west variation to determine magnetic courses and headings, and for drift calculations.

The back of the computer consists of the dead reckoning circular slide rule. The outer, stationary scale is designated the "miles" scale. The movable part of the slide rule contains the time scales, the outer scale being in "minutes" the inner in "hours." Adjacent to the time scales are two cut-outs with corresponding scales, one for determining true airspeed and the other for altitude computations.

EXPLANATION OF THE CIRCULAR SLIDE RULE

The slide rule face of the Dalton E-6B is standard with all major types of navigation computers. It may be used for problems involving:

(1) Fuel Consumption
(2) Time, Speed and Distance
(3) Multiplication, Division and Proportion
(4) Correction of Altitude and Airspeed with
    Temperature and Altitude
(5) Distance Conversions
(6) The Radius of Action Formula
(7) Miscellaneous Calculations.

On the computer, as with any type of slide rule, the figures on the scales represent multiples of ten of the values shown. For example: the figure 24 on the miles scale may represent .24, 2.4, 24, 240, or 2400 miles; and the figure 24 on the minutes scale may represent .24, 2.4, 24, 240, or 2400 minutes. Minutes can be converted to hours by referring to the adjacent "hour" scale. Thus, from the above example, 240 minutes would be read on the corresponding hour scale as four hours, and 2400 minutes as forty hours.

Care should be taken with the reading of the computer and the relative values kept in mind. For example: the numbers 21 and 22 on the distance scale are separated by 5 division lines, or spaced 2 units apart, so that reading at the second division past 21, the correct reading would be 21.4, 214, 2140, etc. The spacing of these divisions should not be hurriedly passed over as the breakdown of the division lines may be into units of 1, 2, 5, or 10.

As the figures on the miles scale can represent any increment, the relation between statute and nautical miles should be observed. Nautical miles and knots (nautical miles per hour) go together and in the same manner statute miles and miles per hour are like related.

DISTANCE CONVERSIONS.

The computer is provided with three indices on the miles scale which set up a proportional relationship between statute miles, nautical miles and kilometers. The mathematical formulas involved are:

1 nautical mile equals 1.15 statute miles.
1 statute mile equals .87 nautical miles.
1 nautical mile equals 1.86 kilometers.
1 statute mile equals 1.61 kilometers.

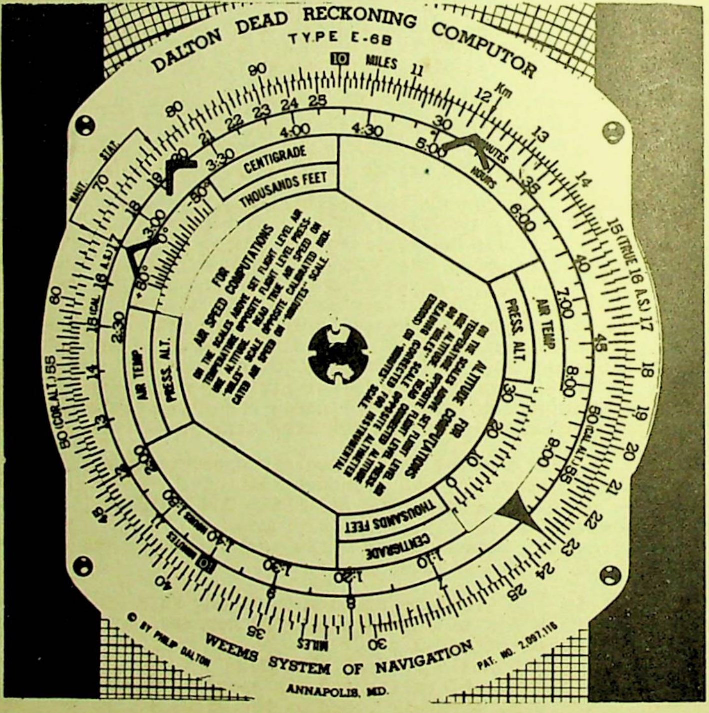
The three indices, or arrows, on the miles scale are located as follows: the nautical arrow marked "Naut" at 66; the statute arrow marked "Stat" at 76; and the kilometer arrow marked "Km" at 122.

Problem Type I: To convert nautical miles to statute miles or kilometers.

(a) Set the number of nautical miles on the minutes scale opposite the "Naut" arrow on the miles scale.
(b) Opposite the "Stat" arrow read the number of statute miles on the minutes scale and opposite the "Km" arrow read the number of kilometers.

Example: Convert 170 nautical miles to statute miles and kilometers.

(a) Set 170 on the minutes scale opposite the "Naut" arrow on the miles scale.
(b) Against the "Stat" arrow read 196 Statute miles and against the "Km" arrow read 315 kilometers. (See Fig. 1)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HOURS
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FOR ALTITUDE COMPUTATIONS
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Fig. 1

Examples for practice:

1. Convert 110 nautical miles to statute miles. To kilometers.
2. Convert 247 knots to miles per hour.
3. How many kilometers in 33 nautical miles?

Problem Type II: To convert statute miles to nautical miles and kilometers.

(a) Set the number of statute miles on the minutes scale against the "Stat" arrow on the miles scale.
(b) Opposite the "Naut" arrow read the number of nautical miles on the minutes scale and opposite the "Km" arrow read the number of kilometers.

Example: Convert 12 statute miles to nautical miles and kilometers.

(a) Set 12 on the minutes scale against the "Stat" arrow.
(b) Opposite the "Naut" arrow read 10.4 nautical miles and opposite the "Km" arrow read 19.2 kilometers.

Examples for practice:

4. Convert 23 statute miles to nautical miles. To kilometers.
5. Convert 84 miles per hour to knots.
6. How many kilometers in 180 statute miles?

AIR DENSITY CORRECTIONS:

Definitions:

Indicated air speed is the speed of the aircraft through the air as read from the air speed indicator.

Calibrated air speed is the indicated air speed corrected for all instrumental errors.

True air speed is the calibrated air speed corrected for variations in temperature and pressure (altitude).

True altitude is the actual altitude of the aircraft above sea level.

Pressure altitude is the altitude of the aircraft above a certain level in the atmosphere where conditions of temperature and pressure are standard. It is the altitude as read from the altimeter when the altimeter setting is 29.92 inches of mercury.

To obtain true air speed, the calibrated air speed must be corrected for variations from standard sea level pressure and temperature. (29.92 inches at 15 degrees centigrade.) Since decrease of temperature with altitude (lapse rate) may vary considerably and sea level pressure is constantly changing, the readings of the air speed indicator are frequently incorrect. The cut-out marked "FOR AIRSPEED COMPUTATIONS" provides a means for correcting calibrated airspeed for these variations from standard conditions. Free air temperature may be read from a strut thermometer and the pressure altitude read from the altimeter by setting to 29.92 inches. It is not strictly necessary to set the altimeter to standard pressure as a large change in altimeter setting will cause only a small error in the true air speed.

Problem Type I: To correct calibrated air speed to true air speed using free air temperature and pressure altitude.

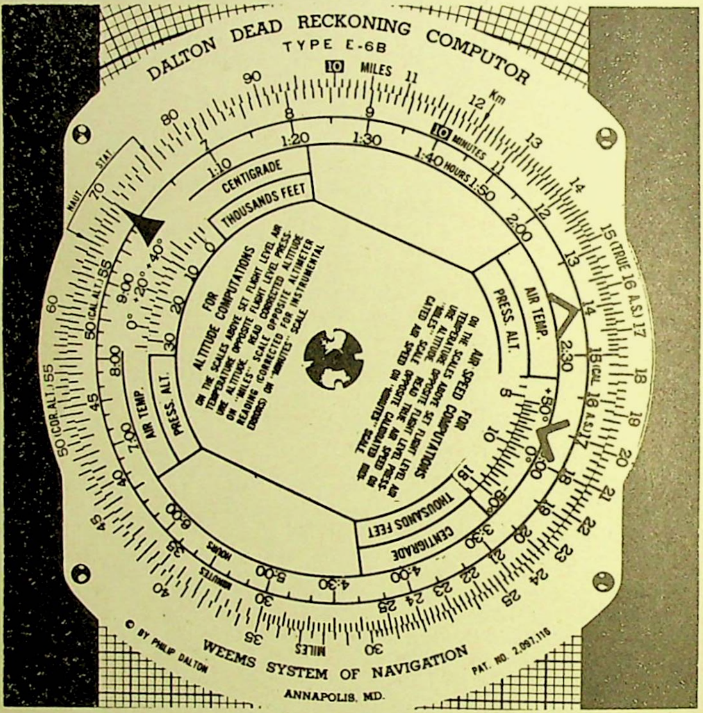
(a) In the cut-out marked "FOR AIR SPEED COMPUTATIONS", set air temperature against pressure altitude.
(b) Read true air speed on the miles scale opposite the calibrated air speed on the minutes scale.

Example: What is the true air speed when flying at 8,000 feet pressure altitude, free air temperature plus 20 degrees centigrade with a calibrated air speed of 140 m.p.h.?

(a) In the cut-out set 8 against plus 20.
(b) Opposite 140 m.p.h. calibrated air speed on the minutes scale, read 164 m.p.h. true air speed on the miles scale. (See Fig. 2, Page 10.)

Examples for practice:

7. Given a pressure altitude of 10,000 feet, temperature 0 degrees centigrade, calibrated air speed 178 knots. What is the true air speed?
8. What is the true air speed when flying at 15,000 feet pressure altitude, temperature minus 20 degrees centigrade, calibrated air speed 160 knots?
9. Given a pressure altitude of 12,000 feet, a temperature of minus 25 degrees centigrade and calibrated air speed of 180 knots, what is the true air speed?
10. What is the true air speed when flying at 8,000 feet pressure altitude, temperature plus 10 degrees centigrade, calibrated air speed 164 miles per hour?



FOR ALTITUDE COMPUTATIONS
ON THE SCALES ABOVE SET FLIGHT LEVEL AIR TEMPERATURE OPPOSITE FLIGHT LEVEL PRESS. ALTITUDE. READ CORRECTED ALTITUDE ON "MILES" SCALE OPPOSITE ALTIMETER READING (CORRECTED FOR INSTRUMENTAL ERRORS) ON "MINUTES" SCALE

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Fig. 2

Alternate method used by the Civil Aeronautics Administration:

Under fairly normal conditions the correction necessary may be found by taking 2% of the calibrated air speed for each thousand feet of pressure altitude and adding this correction to the calibrated air speed to obtain true air speed. While this method will give approximate results in ordinary cases, it is not sufficiently accurate for precision navigation.

Problem Type II: To correct calibrated air speed to true air speed for altitude only.

(a) Set the number 10, on the minutes scale, against the calibrated air speed on the miles scale.
(b) Read true air speed against 100 plus twice the thousands of feet on the minutes scale.

Example: What is the true air speed when flying at 8,000 feet pressure altitude at a calibrated air speed of 125 knots?

(a) Set 10 on the minutes scale against 125 on the miles scale.
(b) Opposite 116 (100 plus 2 times 8) on the minutes scale read the true air speed, 145 knots, on the miles scale.(See Fig. 3)

Examples for practice:

11. When flying at 23,000 feet pressure altitude at a calibrated air speed of 206 knots, temperature unknown, what is the true air speed?
12. When flying at 15,000 feet pressure altitude at a calibrated air speed of 188 miles per hour, temperature unknown, what is the true air speed?
13. When flying at 38,000 feet pressure altitude at a calibrated air speed of 236 knots, what is the true air speed?

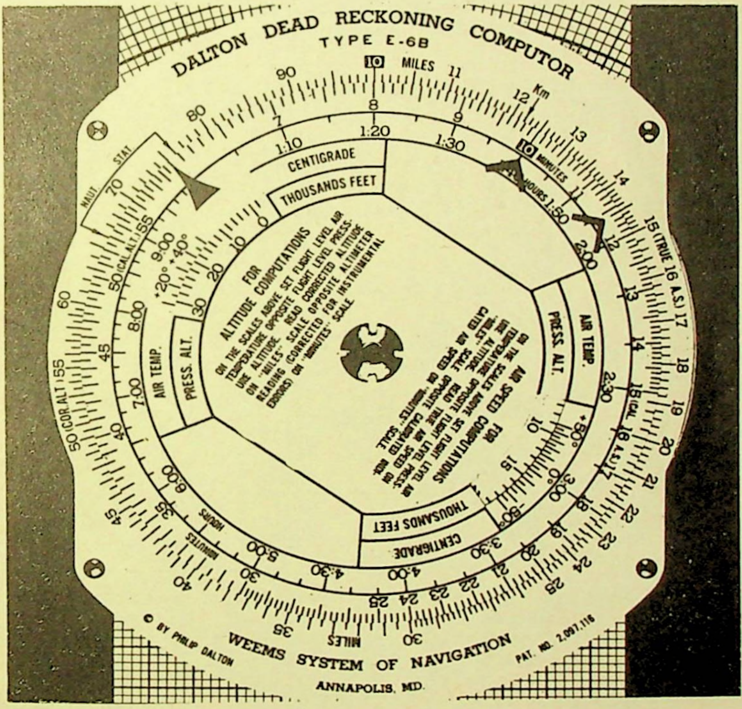


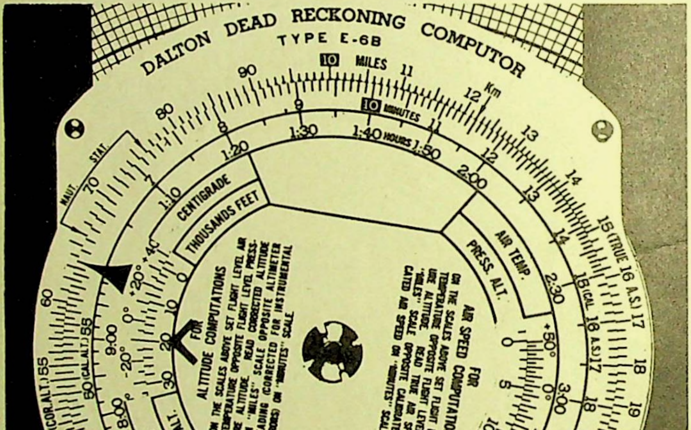
Fig. 3

ALTIMETER CORRECTIONS.

The altimeter is constructed to read the correct altitude under standard conditions of pressure and temperature. As atmospheric conditions are seldom standard, the altimeter reading usually must be corrected. The E-6B computer is provided with a cut-out scale marked "FOR ALTITUDE COMPUTATIONS" to determine this correction. Indicated altitude can be read from the altimeter directly and the pressure altitude can be read by setting to 29.92. The indicated altitude is the altimeter reading when the altimeter setting is adjusted to the ground station pressure corrected to sea level pressure. It is the reading of the instrument when it is set to read elevation of the field on take-off.

Problem Type I: To find true altitude knowing indicated altitude, pressure altitude and free air temperature.
(a) In the cut-out marked "FOR ALTITUDE COMPUTATIONS", set the free air temperature opposite the pressure altitude.
(b) Opposite the indicated altitude on the minutes scale, read the true altitude on the miles scale.

Example: What would be the true altitude of an aircraft flying at an indicated altitude of 20,800 feet, a pressure altitude of 20,000 feet and a temperature of minus 10 degrees centigrade?
(a) In the cut-out, set minus 10 degrees against 20,000 ft.
(b) Opposite 20,800 on the minutes scale, read the true altitude, 22,000 feet on the miles scale. (See Fig. 4)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STAT.
Km
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Fig. 4

Examples for practice:

14. What would be the true altitude of an aircraft flying at an indicated altitude of 15,500 feet, a pressure altitude of 15,000 feet with the temperature 0 degrees centigrade?
15. What would be the true altitude of an aircraft flying at an indicated altitude of 18,000 feet, a pressure altitude of 17,000 feet and the temperature minus 10 degrees centigrade?
16. What would be the true altitude of an aircraft flying at an indicated altitude of 30,500 feet, a pressure altitude of 30,000 feet, at a temperature of minus 30 degrees centigrade?

Alternate method for altimeter correction:

The alternate method of altimeter correction, while more accurate than type I problem, necessitates information which can seldom be obtained in flight. In addition to flight level pressure altitude, indicated altitude and temperature, ground level temperature and pressure altitude must be known.

Problem Type II: To find true altitude knowing indicated altitude and average ground and flight level altitudes and temperatures.

(a) Find average pressure altitude, $\frac{1}{2}$ (pressure altitude aloft plus pressure altitude ground level) and average temperature, $\frac{1}{2}$ (flight level temperature plus ground level temperature). Set

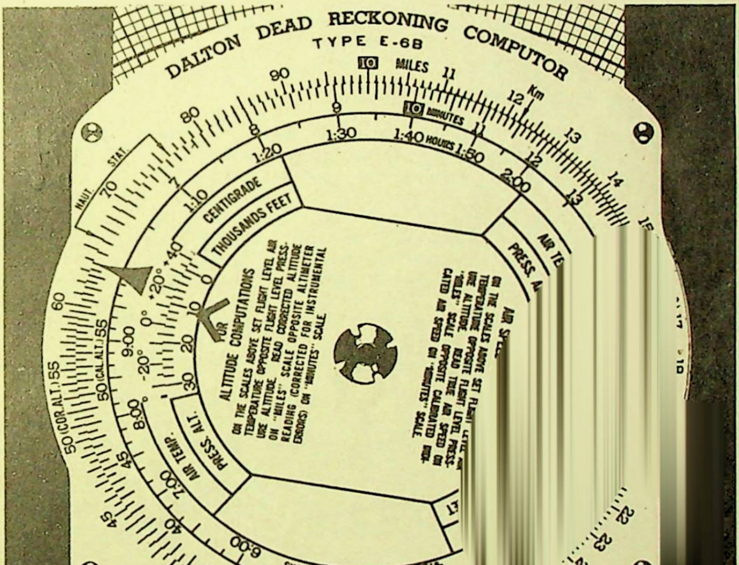
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Fig. 5

average pressure against average temperature in the cut-out marked "FOR ALTITUDE COMPUTATIONS."

(b) Read true altitude on the miles scale opposite the indicated altitude on the minutes scale.

Example: Find the true altitude knowing indicated altitude 20,800 feet, flight level pressure altitude 20,000 feet, flight level temperature minus 10 degrees centigrade; ground level pressure altitude 2,000 feet and ground level temperature plus 30 degrees centigrade.

(a) Set average pressure altitude of 11,000 feet, ½ (2,000 plus 20,000) against average temperature of plus 10 degrees, ½ (minus 10 degrees plus 30 degrees).

(b) Opposite the indicated altitude 20,800 feet on the minutes scale, read true altitude 22,100 feet on the miles scale. (See Fig. 5, Page 13 .)

Examples for practice:

17. Find true altitude knowing indicated altitude 10,500 feet, pressure altitude 9,900 feet, temperature 0 degrees centigrade. Ground level pressure altitude 1,700 feet and ground level temperature plus 30 degrees centigrade.
18. Find true altitude knowing indicated altitude 28,400 feet, pressure altitude 29,200 feet, flight level temperature minus 20 degrees centigrade. Ground level pressure altitude 800 feet and ground level temperature plus 40 degrees centigrade.

RATE TIME DISTANCE PROBLEMS.

The circular slide rule side of the E-6B Computer solves problems involving time, ground speed and distance. The formulas involved are:

Distance equals ground speed multiplied by time. D=ST
Ground speed equals distance divided by time. S=D/T
Time equals distance divided by ground speed. T=D/S

The outside or miles scale is used for all distance units and for rates, as miles per hour or knots. On the time scales a large black arrow replaces the 60 minute and one hour markings. This arrow is known as the "speed arrow" and will hereafter be referred to as such.

Problem Type I: To find the ground speed, knowing the distance run and the time of flight.

(a) Set time on the minutes scale opposite distance run on the miles scale.

(b) Read ground speed on the miles scale opposite the speed arrow.

Example: You want to determine ground speed knowing you have passed two check points 24 miles apart in 12 minutes.

(a) Set 12 on the minutes scale opposite 24 on the miles scale.

(b) On the miles scale read ground speed, 120 m.p.h., opposite the speed arrow. (See Fig. 6, Page 15 .)

Examples for practice:

19. What is your ground speed, having passed two check points 91 miles apart in 52 minutes?
20. A pilot passes two check points 89 miles apart in 35 minutes. What is his ground speed?
21. What ground speed are you making good if you pass two check points 21 miles apart in 8 minutes?

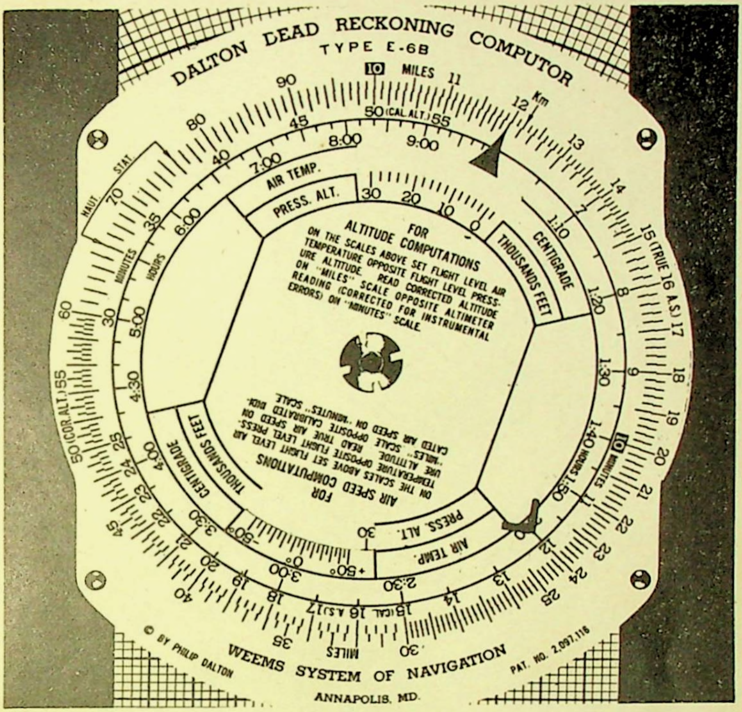
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Fig. 6

Problem Type II: To find time of flight knowing distance flown and ground speed.

(a) Set the speed arrow opposite the ground speed on the miles scale.

(b) Read time of flight on the minutes scale opposite distance flown on the miles scale.

Example: You are 80 nautical miles from your destination and making good a ground speed of 145 knots. What will be the time of flight to destination?

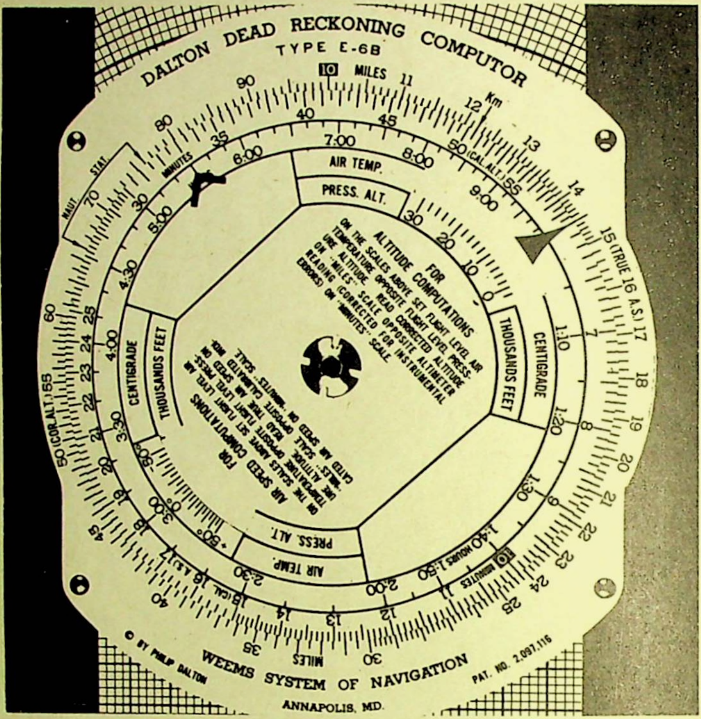
(a) Set the speed arrow on 145.

(b) Opposite 80 on the miles scale read the time, 33 minutes, on the minutes scale. (See Fig. 7, Page 16.)

Examples for practice:

22. You find yourself 168 miles from destination and know the ground speed to be 210 miles per hour. What is the time of flight to destination?
23. How long would it take a plane to go 240 miles at a ground speed of 137 miles per hour?
24. You find yourself 140 miles from destination and know the ground speed to be 109 miles per hour. What is the time of flight to

destination?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HOURS
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Fig. 7

Problem Type III: To find distance run, knowing ground speed and time.

(a) Set the speed arrow opposite the ground speed on the miles scale.

(b) Read distance on the miles scale opposite time on the minutes scale.

Example: You have been flying for 1 hour and 32 minutes at a ground speed of 137 knots. What is the distance flown?

(a) Set the speed arrow on 137.

(b) Read distance, 210 nautical miles, opposite 1:32 on the minutes scale. (See Fig. 8, Page 17.)

Examples for practice:

25. A plane has been flying for 2 hours and 34 minutes at a ground speed of 363 knots. What is the distance flown?
26. A pilot flies for 13 minutes at a ground speed of 129 miles per hour. What is the distance flown?
27. A plane has been flying at a ground speed of 108 knots for 25 minutes. What is the distance flown?

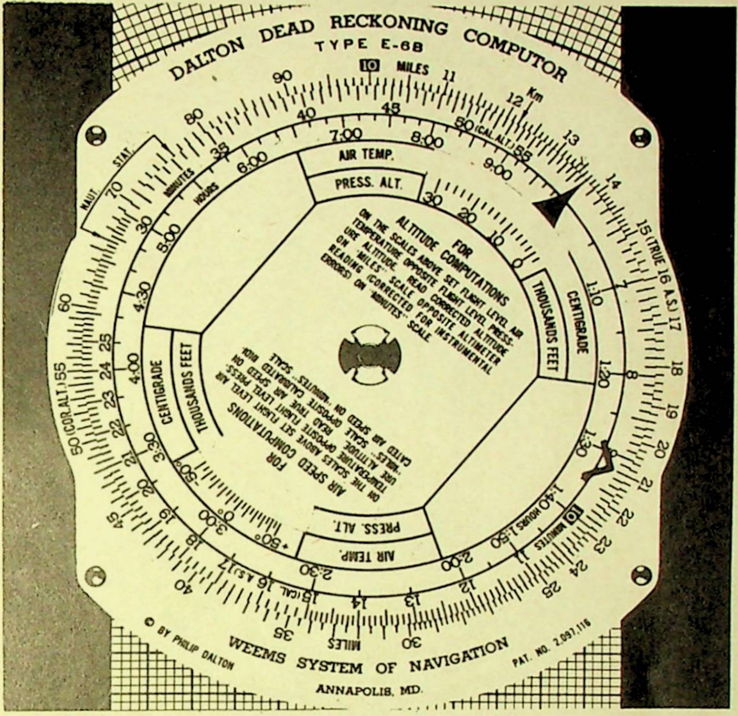
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Fig. 8

FUEL CONSUMPTION.

The miles and minutes scale of the computer may be used for all problems involving fuel consumption. The minutes scale is used to set up the time unit and miles scale for gallons of fuel and rate of consumption.

Problem Type I: To find rate of consumption, knowing total gallons used in a certain time.
(a) Set the number of gallons on the miles scale opposite the time on the minutes scale.
(b) Read rate of consumption on the miles scale opposite the speed arrow.

Example: After flying for 40 minutes a pilot finds that 75 gallons of gas have been used. What is the rate of fuel consumption?
(a) Set 75 on the miles scale opposite 40 on the minutes scale.
(b) Read rate of consumption on the miles scale, 112½ gallons per hour, opposite the speed arrow. (See Fig. 9, Page 18.)

Examples for practice:

28. After flying for 1 hour and 35 minutes the pilot notices that 88 gallons of gas have been used. What is the rate of fuel con-

sumption?

29. After flying for 24 minutes, 36 gallons of fuel have been used. What is the rate of consumption?
30. 45 gallons of gas have been used in 13 minutes. What is the rate of fuel consumption?

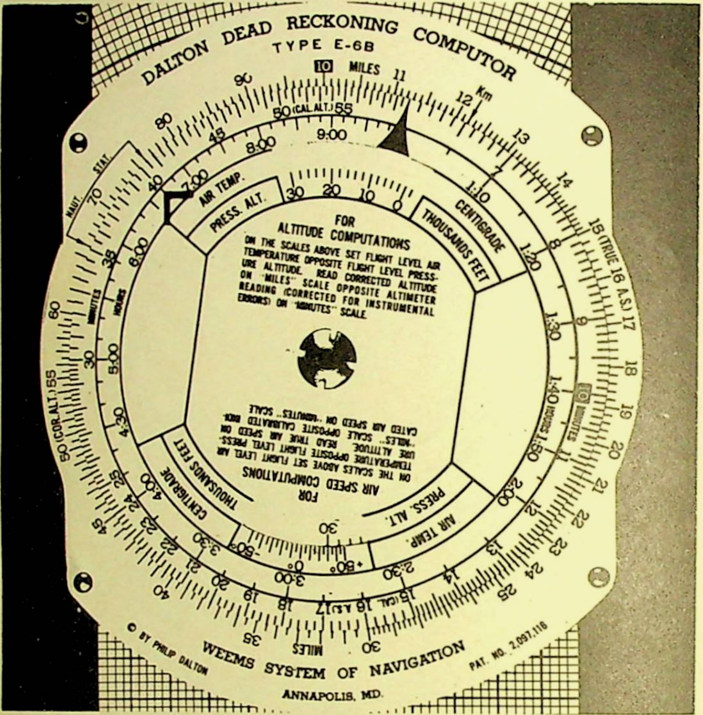
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Fig. 9

Problem Type II: To find time of flight, knowing total fuel load and rate of consumption.

(a) Set the speed arrow opposite the rate of consumption on the miles scale.
(b) Read time of flight on the minutes scale opposite the total load in gallons on the miles scale.

Example: A plane carries 650 gallons and uses gas at the rate of 116 gallons per hour. How long would the gasoline last under these conditions?

(a) Set the speed arrow against 116.
(b) Read the time, 5 hours 35 minutes, on the minutes scale opposite 650 on the miles scale. (See Fig. 10, Page 19 .)

Examples for practice:

31. A plane carries 130 gallons of gasoline and uses gas at the rate of 31 gallons per hour. How long will the gas last under these conditions?

32. A plane carries 440 gallons of gas and rate of consumption is 88 gallons per hour. How long will the gasoline last?
33. A plane which carries 640 gallons of gasoline uses the fuel at the rate of 132 gallons per hour. How long will the fuel last?

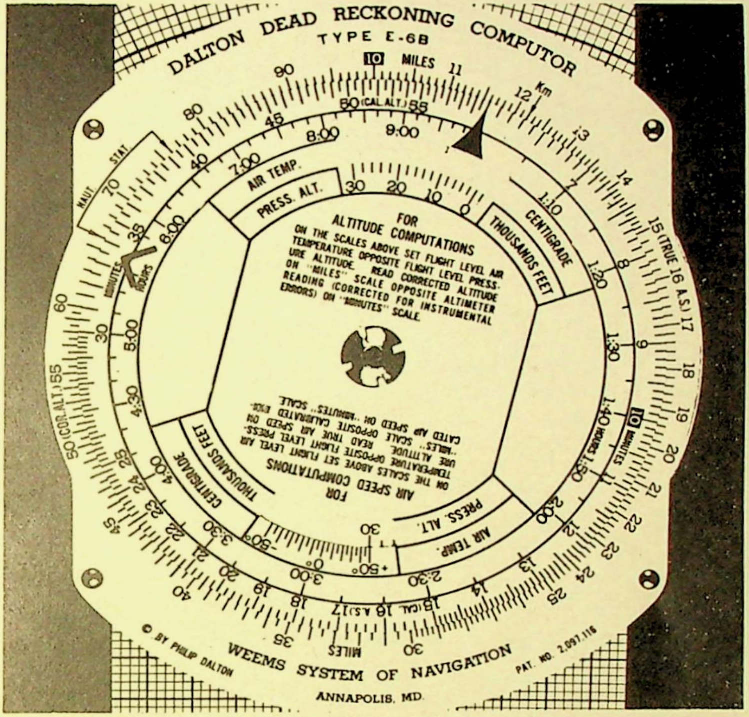
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Fig. 10

Problem Type III: To find how much fuel will be used in a certain time knowing rate of consumption.
(a) Set the speed arrow opposite the rate of consumption.
(b) Read the gallons consumed, on the miles scale, opposite the time on the minutes scale.

Example: How many gallons of gas will be used in a 3½ hour flight with a rate of consumption of 129 gallons per hour?
(a) Set the speed arrow on 129.
(b) On the miles scale read the number of gallons consumed, 452, opposite 3:30 on the hours scale. (See Fig. 11, Page 20.)

Examples for practice:

34. How many gallons of gasoline would be used in a 33 minute flight with a fuel rate of consumption of 115 gallons per hour?
35. With a fuel rate of consumption of 162 gallons per hour how much gas would be used in 1 hour and 14 minutes?
36. How many gallons of gas would be used in a flight of 4 hours and

8 minutes with a rate of consumption of 23 gallons per hour?

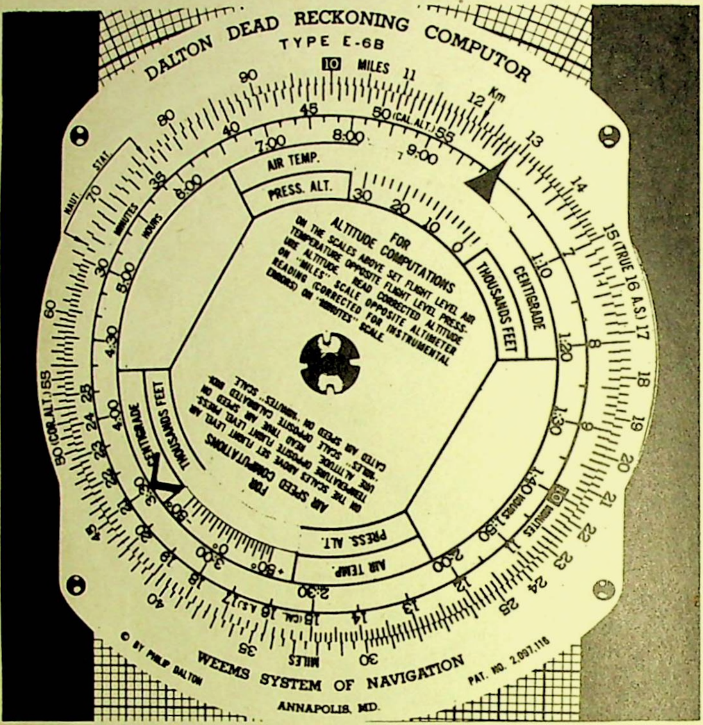
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Fig. 11

MULTIPLICATION AND DIVISION

Problems in multiplication and division can be solved on the E-6B computer since the miles and minutes scales of the computer correspond to the "C" and "D" scales of the ordinary slide rule. In problems involving decimal fractions, the decimal point should be ignored in setting up the values, but must be properly placed at the end of the calculation.

Problem Type I: Multiplication.

(a) Set the number to be multiplied on the miles scale opposite the number 10 on the minutes scale.
(b) Read the result on the miles scale opposite the multiplier on the minutes scale.

Example: Multiply 24 by 55.

(a) Set 24 on the miles scale opposite 10 on the minutes scale.
(b) Read the result, 1320, on the miles scale opposite 55 on the minutes scale. (See Fig. 12, Page 21.)

Examples for practice:

37. Multiply 92 by 26.

38. Multiply 83 by 62.
39. Multiply 103 by 18.
40. Multiply 23.6 by 6.3.

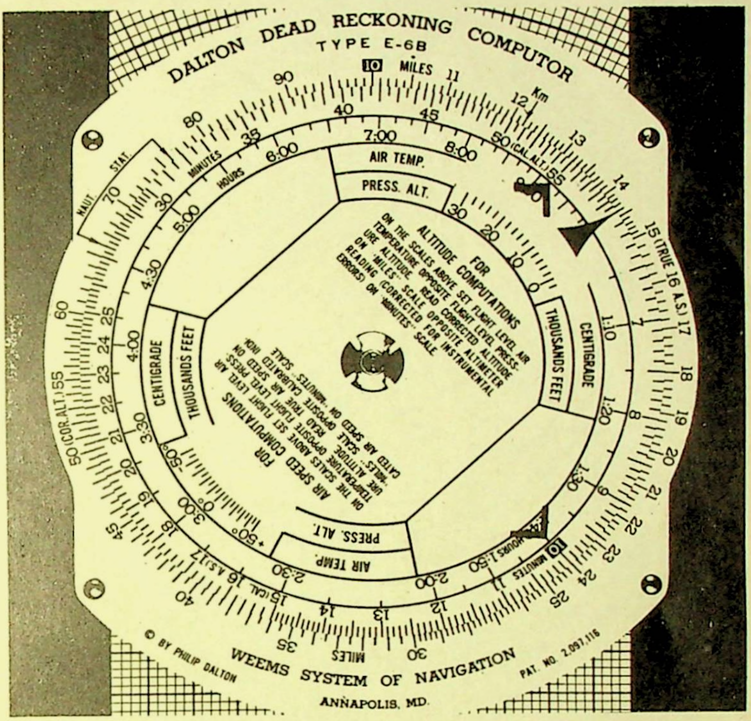
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Fig. 12

Problem Type II: Division.
(a) Set the number to be divided on the miles scale opposite the divisor on the minutes scale.
(b) Read the answer on the miles scale opposite the number 10 on the minutes scale.

Example: Divide 816 by 40.
(a) Set 816 on the miles scale opposite 40 on the minutes scale.
(b) Read the answer, 20.4, on the miles scale opposite the number 10 on the minutes scale. (See Fig. 13, Page 22.)

Examples for practice:

41. Divide 203 by 16.
42. Divide 4.62 by 22.
43. Divide 881 by 73.

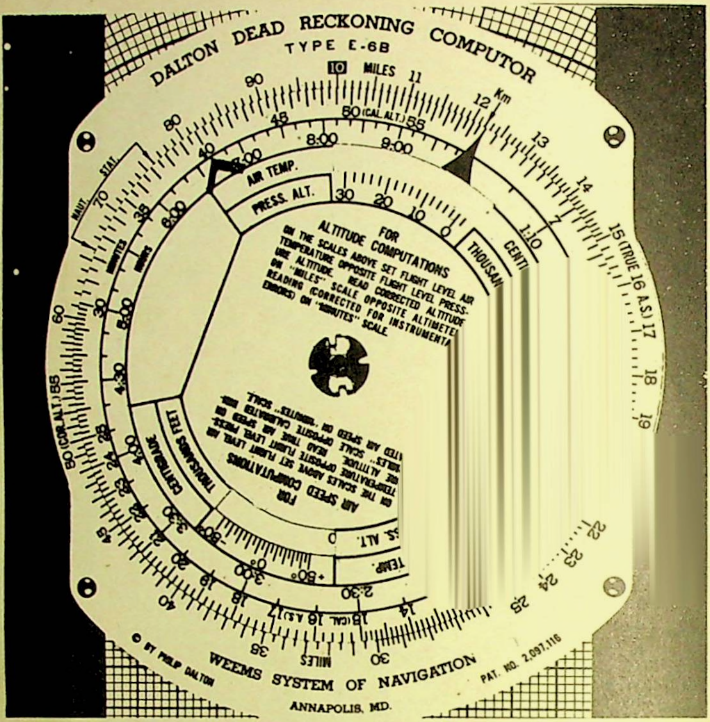
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Fig. 13

RADIUS OF ACTION FORMULA.

Radius of action to the same base, radius of action to a moving base and alternate airport problems may be solved using the following formulas:

$$t \text{ equals } \frac{GS2 \text{ X } T}{GS1 \text{ plus } S2} \text{ and R/A equals t multiplied by GS1.}$$

Where:
t equals the time out (time to turn).
S1 equals the rate of departure.
S2 equals the rate of closure.
T equals the net fuel hours.
GS1 equals the ground speed out.
GS2 equals the ground speed in.
R/A equals the radius of action.

In Radius of Action to the same base, the ground speeds equal the rates of departure and closure so that GS1 and GS2 are substituted for S1 and S2 in the formula.

RADIUS OF ACTION FORMULA

Problem Type: Radius of Action. (Formula.)
(a) Set the sum of S1 and S2 on the miles scale opposite S2 on the minutes scale.
(b) Opposite the net fuel hours (T) in minutes on the miles scale, read the time out (t) on the minutes scale.
(c) Set the speed arrow against ground speed out (GS1).
(d) Read the radius of action (R/A) on the miles scale opposite time out (t) on the minutes scale.

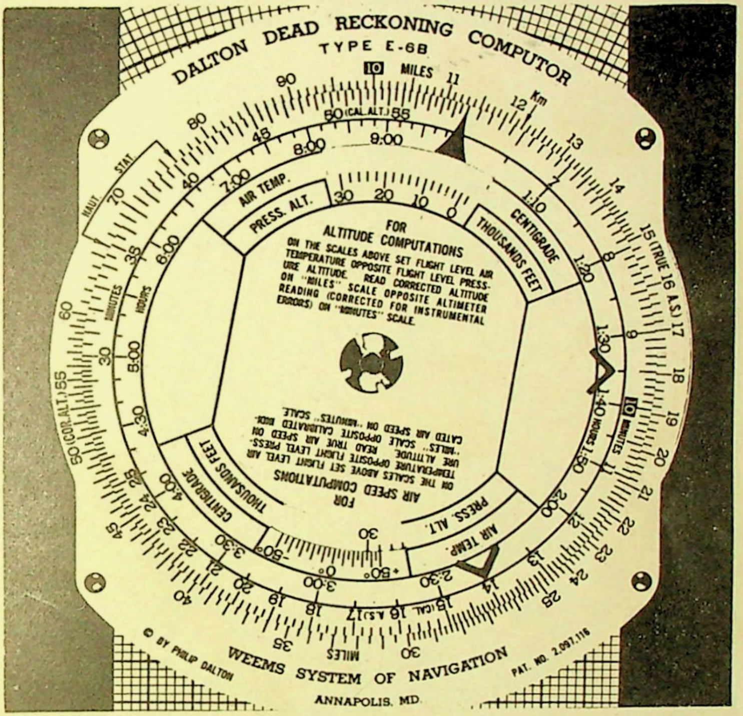
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Fig. 14

Example: In a radius of action to the same base, the navigator finds that the ground speed out is 125 knots and the ground speed back is 140 knots. Net fuel hours is 3. What is the time out (t) and the radius of action?
(a) Set 265 (140 plus 125) on the miles scale opposite 140 on the minutes scale.
(b) Read the time out, 1 hour 35 minutes, on the minutes scale opposite 180 (3 hours) on the miles scale. (See Fig. 14.)
(c) Set the speed arrow against 125 on the miles scale.
(d) Read the radius of action, 198 nautical miles, opposite 1:35 on the minutes scale. (See Fig. 15, Page 24.)

Examples for practice:

44. In an alternate airport problem, the pilot finds that S1 equals

138 knots, S2 equals 124 knots, GS1 is 153 knots and the net fuel hours is 5. What is the time out and the radius of action?

45. In a radius of action to the same base the pilot finds that GS1 equals 180 m.p.h., GS2 equals 98 m.p.h. and net fuel hours is 4½. What is the time out and the radius of action?
46. In an alternate airport problem, the navigator finds that S1 equals 35 knots, S2 equals 166 knots, GS1 equals 135 knots and T equals 6¼ hours. What is the time out and the radius of action?
47. In a radius of action to a moving base the navigator finds that S1 equals 203 knots, S2 equals 107 knots, GS1 equals 173 knots and T equals 2 hours 45 minutes. What is the time out and the radius of action?

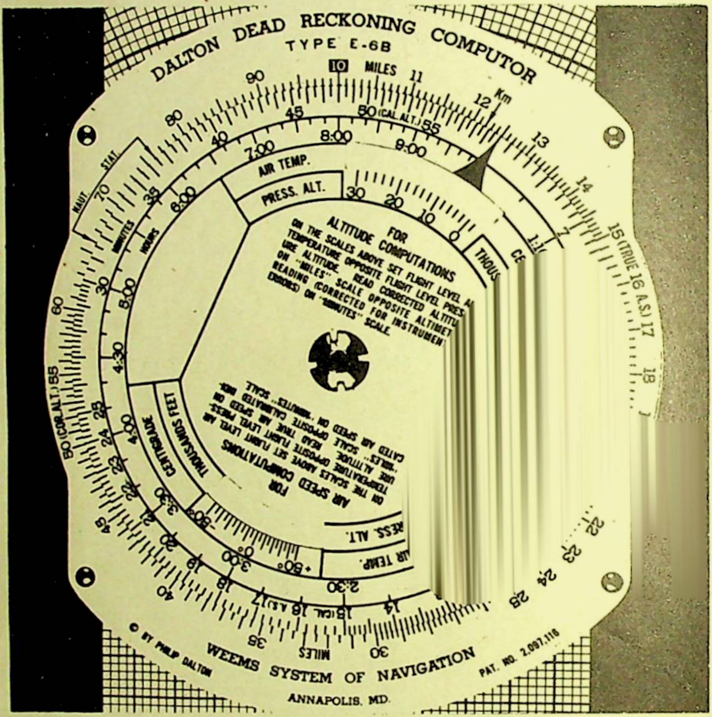
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Fig. 15

MISCELLANEOUS CALCULATIONS.

Problem Type I: To solve ground speed by timing formula.

Ground Speed equals $\dfrac{\text{H times Factor}}{\text{t}}$

Where:
H equals the absolute altitude. (Altitude above ground.)
t equals the time in seconds.
Factor is found in provided tables. (See page 114.)

(a) Opposite the absolute altitude on the miles scale set the time in seconds on the minutes scale.
(b) Read the ground speed on the miles scale opposite the factor on the minutes scale.

Example: When flying at 10,000 feet absolute altitude, a navigator swings the drift meter through 25 degrees in 35 seconds and finds the factor to be .310. What is the ground speed?
(a) Set 10 on the miles scale opposite 35 on the minutes scale.
(b) Read ground speed, 88.5 knots, on the miles scale opposite .31 on the minutes scale. (See Fig. 16.)

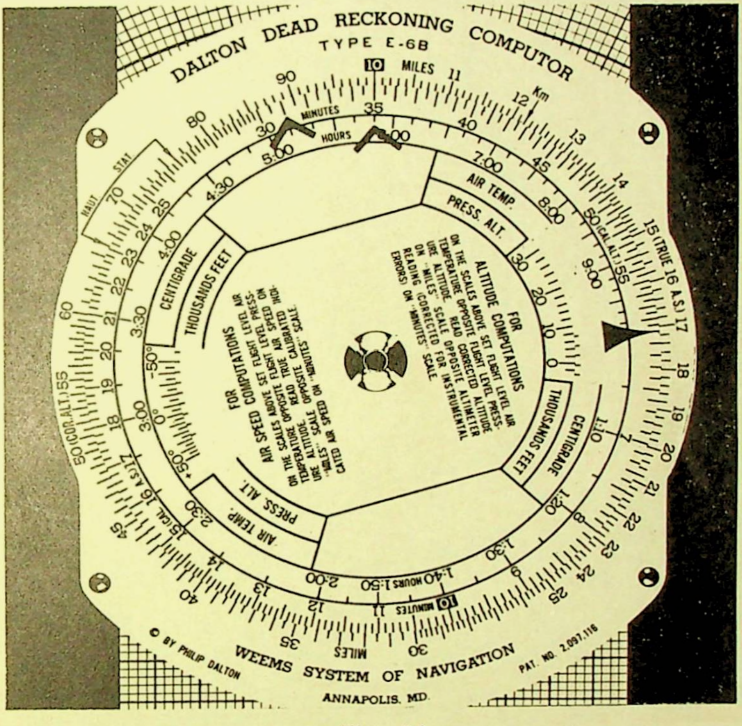
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Fig. 16

Examples for practice:

48. Flying at 3,000 feet absolute altitude, a navigator swings the drift indicator through 40 degrees in 28 seconds, and finds the factor in the nautical mile table to be .810. What is the ground speed in knots?
49. Knowing absolute altitude 8,000 feet, time 22 seconds and factor from the statute miles table is .650, what is the ground speed?

Problem Type II: To convert hundredths to sixtieths.
(a) Set the number of hundredths on the miles scale opposite the number 10 on the minutes scale.
(b) Read the number of sixtieths on the miles scale opposite the

speed arrow.

Example: Convert 34 hundredths of an hour to minutes.
(a) Set 34 on the miles scale opposite 10 on the minutes scale.
(b) Read the number of minutes, 20.4, on the miles scale opposite the speed arrow. (See Fig. 17.)

Note: Sixtieths can be converted to hundredths by reversing the above procedure, i.e., set the number of sixtieths opposite the speed arrow and read the answer in hundredths on the miles scale opposite 10 on the minutes scale.

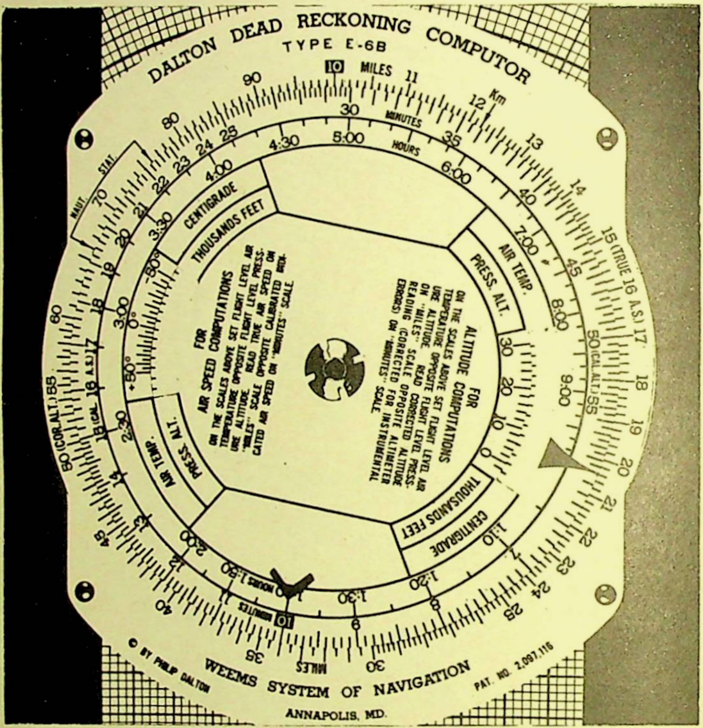
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Fig. 17

Examples for practice:

50. Convert 64/100 hours to minutes.
51. Convert 80/100 hours to minutes.
52. Convert 27 minutes to hundredths of an hour.
53. Convert 18 minutes to hundredths of an hour.

Problem Type III: To determine the net fuel hours (T) by taking 75% of the total fuel hours.
(a) Set the total fuel hours on the minutes scale opposite the number 10 on the miles scale.
(b) Read the net fuel hours (T) on the minutes scale opposite the number 75 on the miles scale.

Example: Find the net fuel hours, knowing your plane carries gas for a total of 6 hours flight and required reserve is 25% of total hours.

(a) Set 6 on the minutes scale opposite 10 on the miles scale.

(b) Read net fuel hours, 4.5, on the minutes scale opposite 75 on the miles scale. (See Fig. 18.)

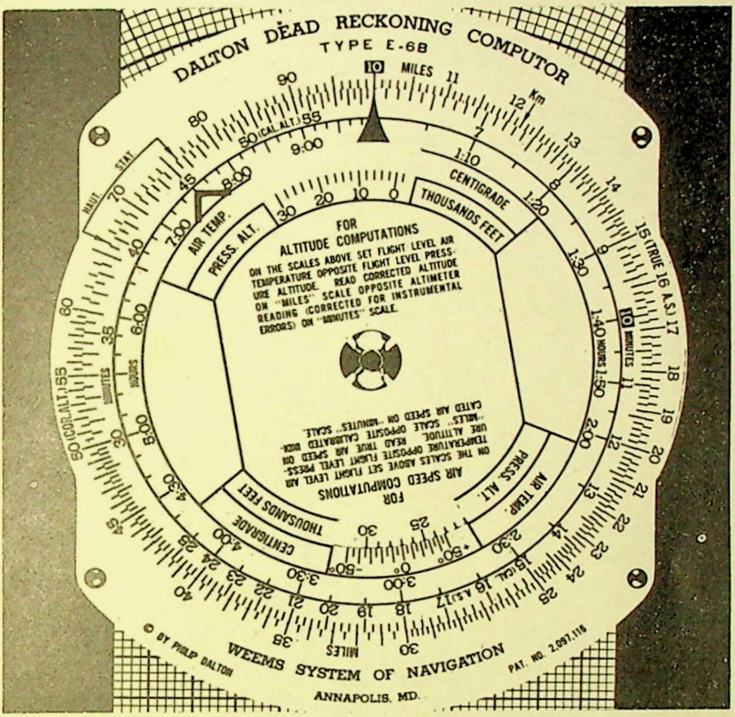
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Fig. 18

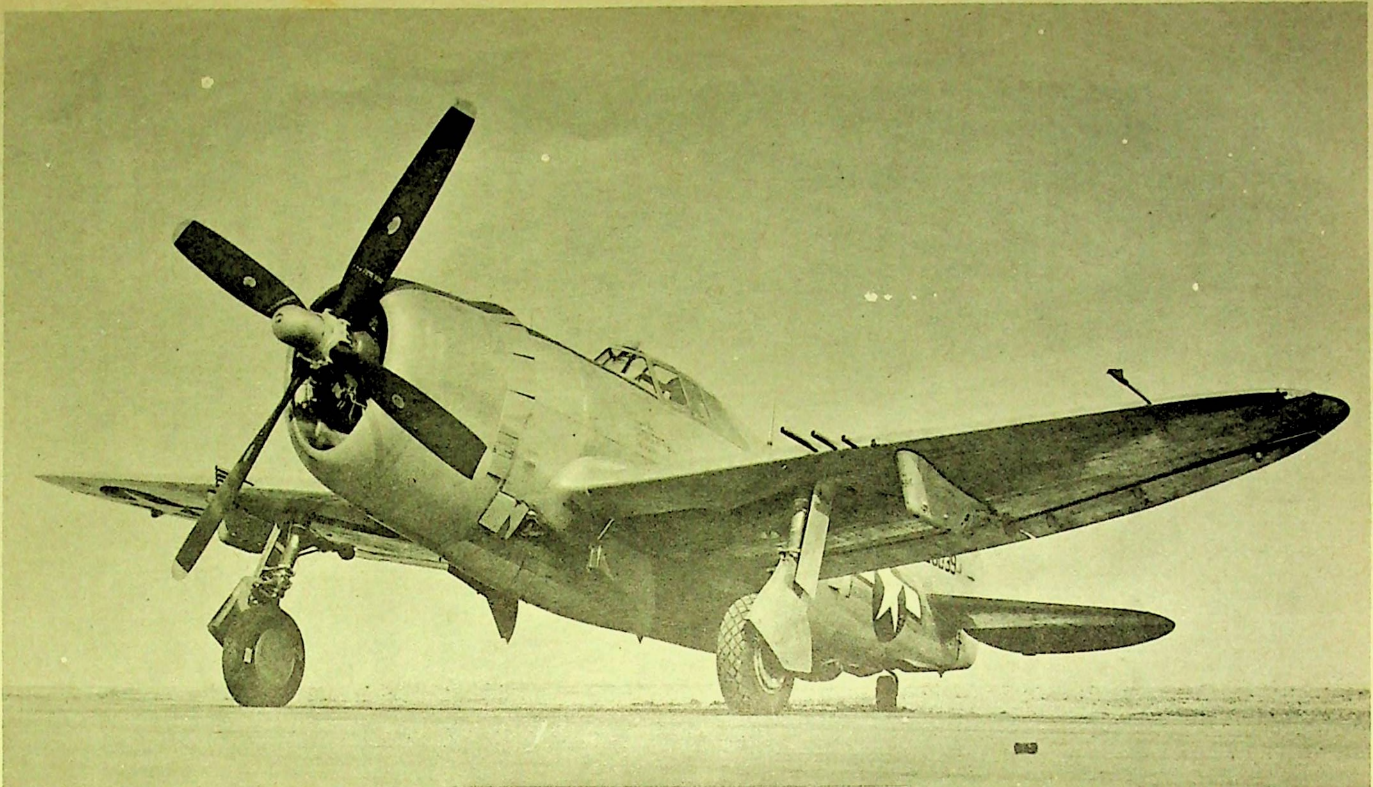
Examples for practice:

54. Determine net fuel hours, knowing total fuel hours is 7 and required reserve 25%.
55. Find the net fuel hours, knowing that total fuel carried will last 9.5 hours and required reserve is 25%.

VECTOR PROBLEMS.

The vector face of the computer can be used to solve the following problem types:

Triangles of velocity
Off course
Double drifts and Drift on Two Headings
Radius of Action to the same base
Radius of Action to a moving base, or
Alternate Airport problem
Interception.



P-47 THUNDERBOLT
(Courtesy Republic Aviation Corporation)

As stated in the description of the E-6B computer, the face of the instrument embodying the transparent plotting disk and the sliding grid scale is used for the solution of vector problems. In setting up the problem the simplest procedure is to use the center line of the grid to represent either true course or true heading, whichever is given. For example, if we are given the true course and required to find the true heading, the center line of the grid would represent the given true course and one of the radiating lines to the right or left of the center line, or course, would represent the required heading.

When plotting the wind vector the following rules must be observed: If given a true course and required to find the true heading, set the direction from which the wind is blowing at the true index. Plot the wind along the center line from a point above the grommet down to the grommet. The arrow-head of the wind line would then be at the grommet. If given a true heading and required to find the true course, again set the direction from which the wind is blowing at the true index, but plot the wind vector from the grommet downward along the center line. The grommet now represents the tail of the wind line.

Whenever the center line of the grid is used to represent the true course, groundspeed will always be read under the grommet. When true heading is set up along the center line true airspeed will always be read under the grommet.

TRIANGLES OF VELOCITIES.

Problem Type I: Given wind direction and force, true heading and true airspeed, to solve for true course and ground speed.

(a) Set direction from which the wind is blowing at the true index.
(b) Plot the wind arrow downward from the grommet using the center line scale to determine the proper length.
(c) Turn the azimuth ring until true heading is opposite the true index.
(d) Set the grommet on true airspeed on the center line scale.
(e) At the arrow-head end of the wind line read ground speed (as indicated by the concentric circle).
(f) From the radiating lines determine the angular difference (drift) between heading and course. (The radiating line passing through the arrow-head end of the wind line is the course line.) If the course is to the right of the heading add the angular value to determine the true course and subtract if course is to the left of the heading. This correction may be applied easily by the use of the variation drift scale as illustrated in the following example.

Example: Given: True heading 126 degrees,
True airspeed 156 miles per hour,
Wind from 70 degrees at 30 miles per hour.
Find: True course and ground speed.

(a) On compass rose, set direction from which wind is blowing, 70 degrees, at the true index. Plot wind downward from the grommet 30 units. (See Fig. 19-A, Page 30.)
(b) Set true heading, 126 degrees, at the true index.
(c) Set the grommet on 156 true airspeed.
(d) At the arrow-head of the wind line read the ground speed, 142 m.p.h., on the concentric circle. (See Fig. 19-B, Page 30.)
(e) From the radiating line passing through the arrow-head end of the wind line, determine angular difference between heading and course. (Course 10 degrees right of heading.)
(f) On the variation-drift scale, adjacent to the 10 degree mark to the right of the true index, read true course, 136 degrees, on azimuth ring.

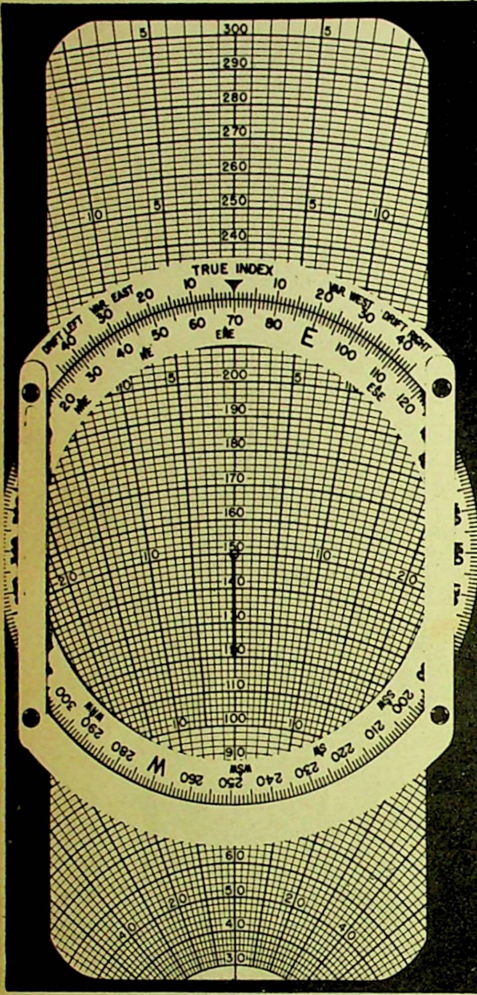


Fig. 19-A

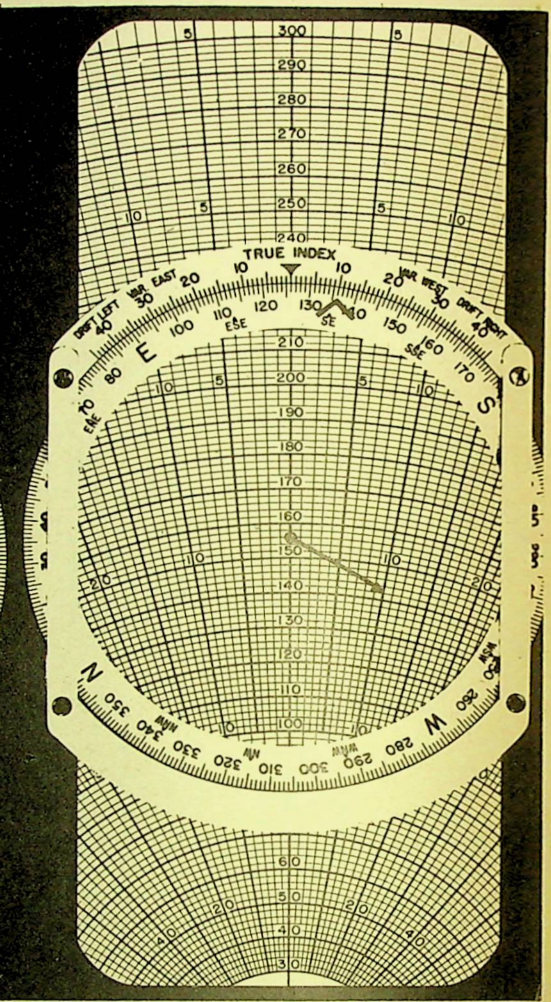
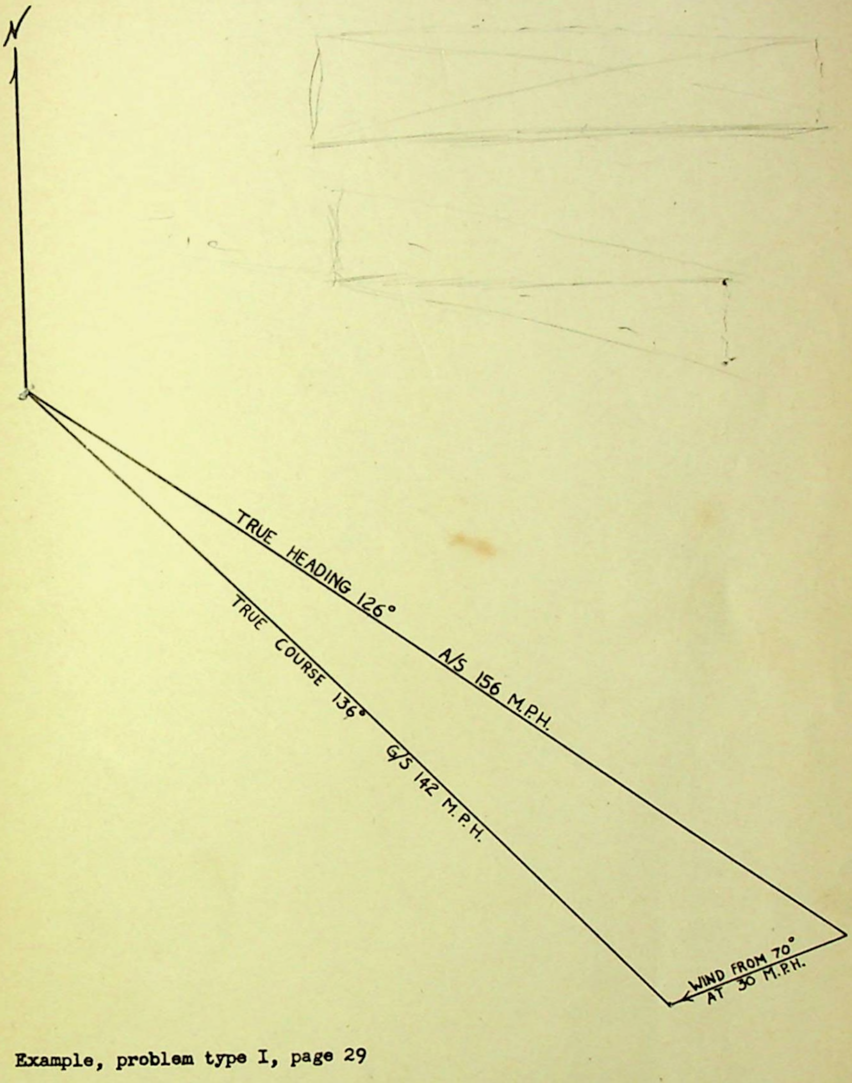


Fig. 19-B

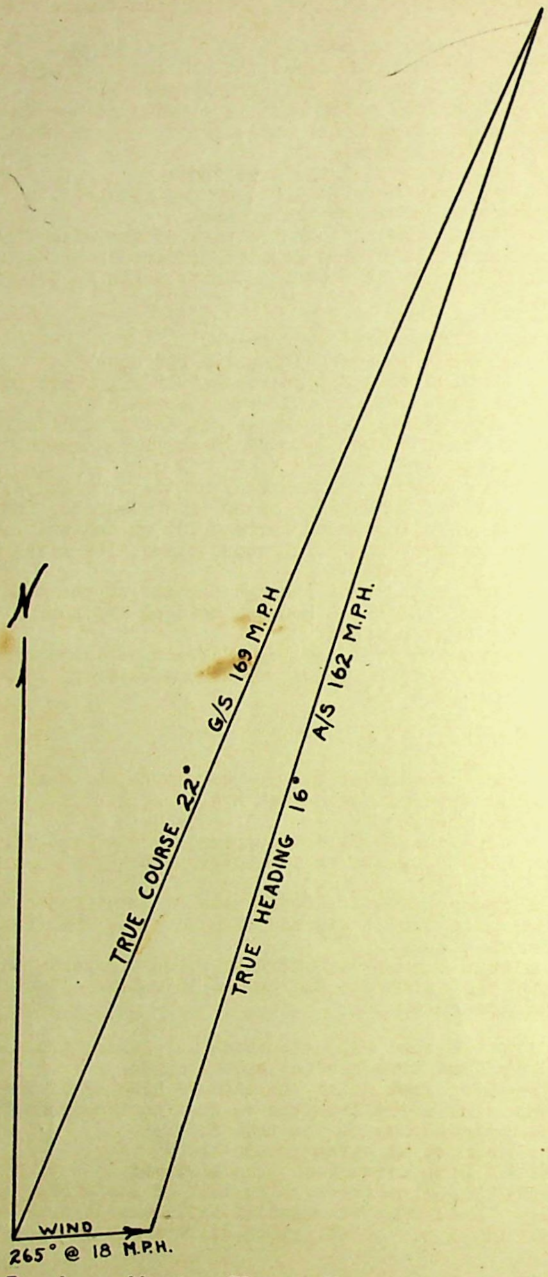
Examples for practice:

56. Given true heading 95 degrees, true airspeed 98 m.p.h.,wind from 213 degrees at 13 m.p.h. Find true course and ground speed.
57. Given a true heading of 290 degrees, true air speed 315 knots, and wind from 290 degrees at 45 knots. Find true course and ground speed.
58. Given a true heading of 10 degrees, true airspeed 292 m.p.h., and wind from 330 degrees at 36 m.p.h., Find true course and ground speed.
59. Given true heading 15 degrees, true airspeed 156 knots, and wind

TRIANGLES OF VELOCITIES



Example, problem type I, page 29


N
TRUE COURSE 22° G/S 169 M.P.H
TRUE HEADING 16° A/S 162 M.P.H.
WIND
265° @ 18 M.P.H.

Example, problem type II, page 33

from 128 degrees at 17 knots. Find true course and ground speed.

Problem Type II: Given: wind direction and force, true course and true airspeed, to find true heading and ground speed.

(a) Set direction from which wind is blowing at the true index.
(b) Plot the wind arrow from above down to the grommet. (Arrow-head of wind at the grommet.)
(c) Set the true course at the true index.
(d) Set the tail of the wind line on true airspeed.
(e) Read ground speed under the grommet.
(f) The radiating line through the tail of the wind line, is the true heading. Determine angular difference between course and heading and apply to variation-drift scale to determine true heading.

Example: Given: True course 22 degrees,
True airspeed 162 miles per hour,
Wind from 265 degrees at 18 miles per hour.
Find: True heading and ground speed.

(a) Set wind direction, 265 degrees, at the true index. Plot wind from above down to the grommet 18 units in length. (See Fig. 20-A, Page 34.)
(b) Set the true course, 22 degrees, at the true index.
(c) Set the tail of the wind line on true airspeed, 162 m.p.h. (Use concentric circle passing through 162 on center line scale.)
(d) Under the grommet read the ground speed, 169 miles per hour. (See Fig. 20-B, Page 34.)
(e) From the radiating line through the end of the wind line, determine angular difference between heading and course. (Heading 6 degrees left of course.)
(f) On the variation drift scale, adjacent to the 6 degree mark to the left of the true index, read true heading, 16 degrees, on azimuth ring.

Examples for practice:

60. Given a true course of 327 degrees, true air speed 174 m.p.h. and a wind from 81 degrees at 8 m.p.h. Find the true heading and ground speed.
61. Given a true course of 305 degrees, true airspeed 156 knots and wind from 200 degrees at 13 knots. Find true heading and ground speed. 160-300
62. Given a true course of 106 degrees, true airspeed 186 miles per hour and wind from 4 degrees at 24 m.p.h. Find the true heading and ground speed. 196-099 191
63. Given a true course of 8 degrees, true airspeed 160 miles per hour and wind from 134 degrees at 15 m.p.h. Find the true heading and ground speed.

Problem Type III: Given: Wind direction and force, true course and ground speed, to find true heading and airspeed.

(a) Set direction from which the wind is blowing at the true index.
(b) Plot the wind arrow from above, down to the grommet.
(c) Set the true course at the true index.
(d) Set the grommet at given ground speed.
(e) At tail of wind arrow read true airspeed.
(f) The radiating line through the tail of the wind line is the true heading. Determine the angular difference between course and heading and apply to variation-drift scale to determine true heading.

Example: Given: True course 220 degrees, ground speed 155 m.p.h. and

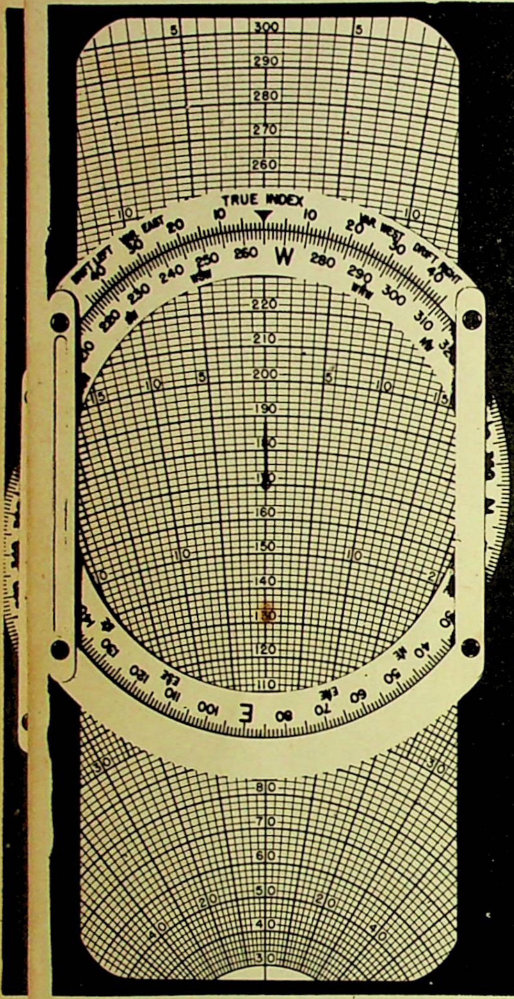


Fig. 20-A

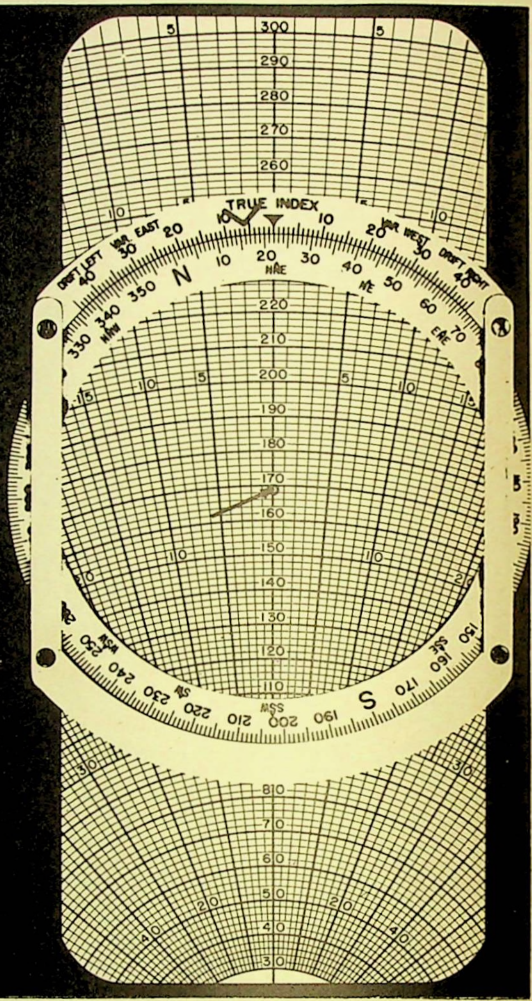
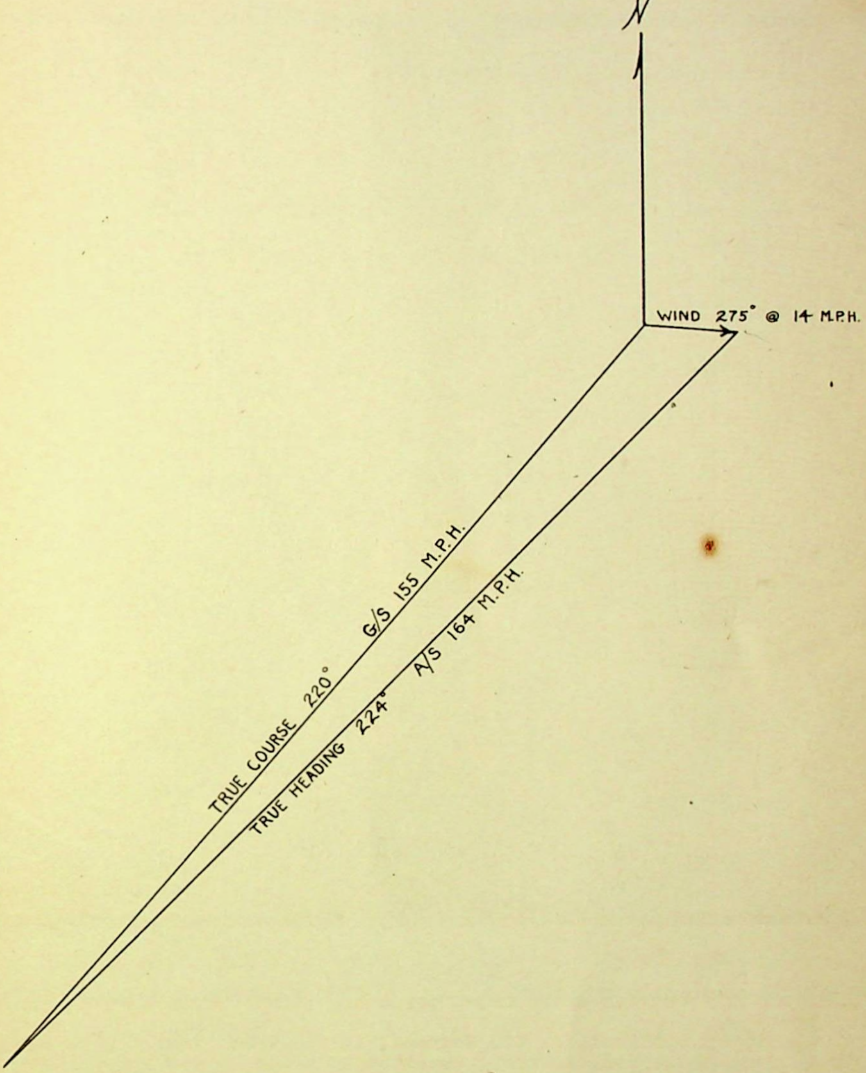


Fig. 20-B

wind from 275 degrees at 14 miles per hour. Find: True heading and airspeed.

(a) Set wind direction, 275 degrees, at the true index. Plot wind from above down to the grommet at 14 m.p.h. (See Fig. 21-A, Page 36.)
(b) Set the true course, 220 degrees, at the true index.
(c) Set the ground speed, 155 m.p.h. under the grommet.
(d) At tail of wind line read true airspeed, 164 m.p.h. on concentric circle. (See Fig. 21-B, Page 36.)
(e) From the radiating line passing through the end of the wind line, determine angular difference between heading and

TRIANGLES OF VELOCITIES


N
WIND 275° @ 14 M.P.H.
TRUE COURSE 220° G/S 155 M.P.H.
TRUE HEADING 224° A/S 164 M.P.H.

Example, problem type III.

course. (Heading 4 degrees right of course.)

(f) On the variation-drift scale adjacent to the 4 degree mark to the right of the true index, read true heading 224 degrees.

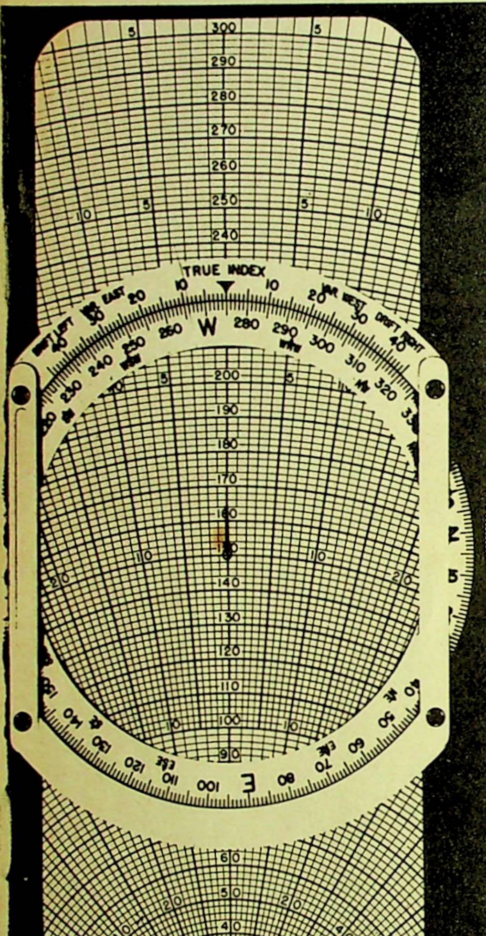


Fig. 21-A

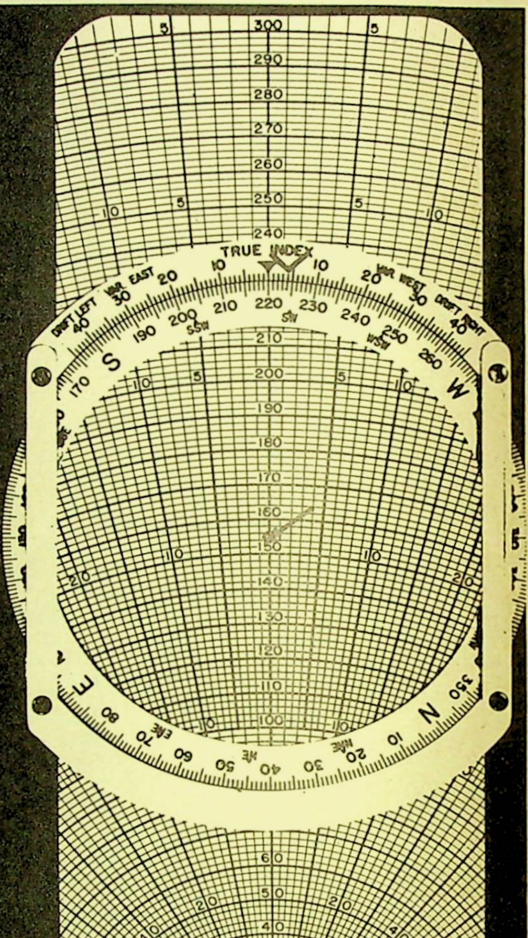


Fig. 21-B

Examples for practice:

64. Given a true course of 70 degrees, ground speed of 140 knots and wind from 20 degrees at 20 knots. Find true heading and true airspeed.
65. Given a true course of 340 degrees, ground speed of 130 knots and wind from 50 degrees at 35 knots. Find true heading and true airspeed.

66. True course is 154 degrees, ground speed 165 m.p.h. and the wind is from 86 degrees at 22 miles per hour. What is the true heading and airspeed?
67. Given true course 30 degrees, ground speed 146 knots and wind from 104 degrees at 30 knots. What is the true heading and true airspeed?

Problem Type IV: To determine the wind, given true course and ground speed, true heading and airspeed.

(a) Set the given true course opposite the true index.
(b) Set the grommet on ground speed.

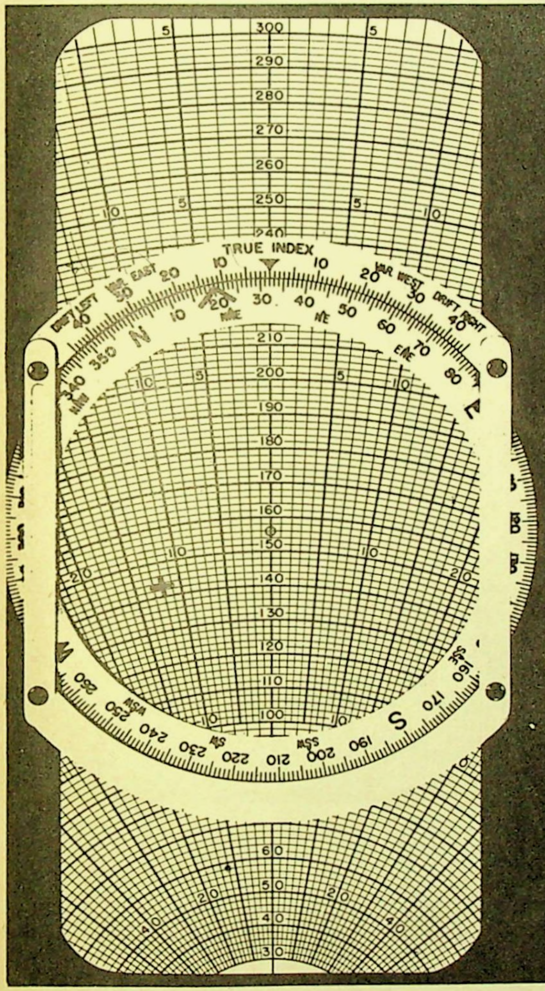


Fig. 22-A

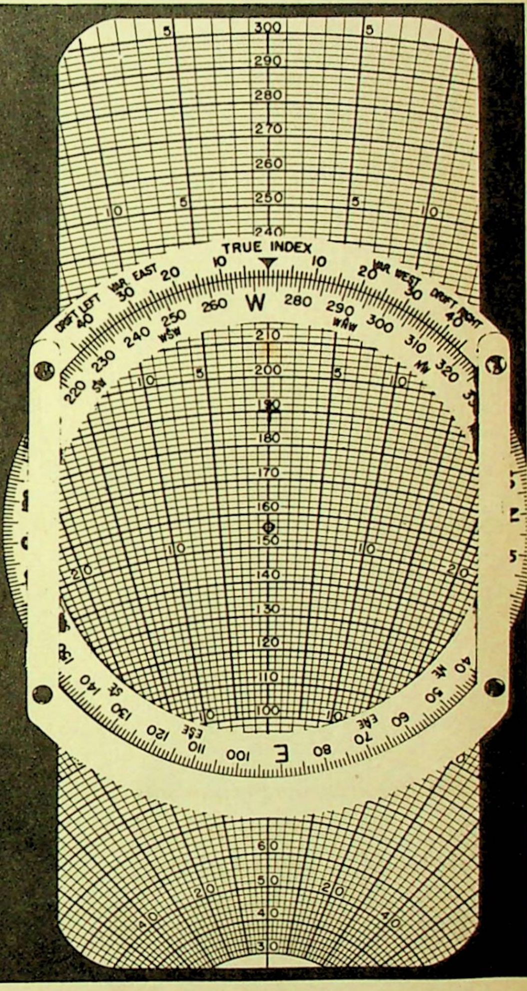
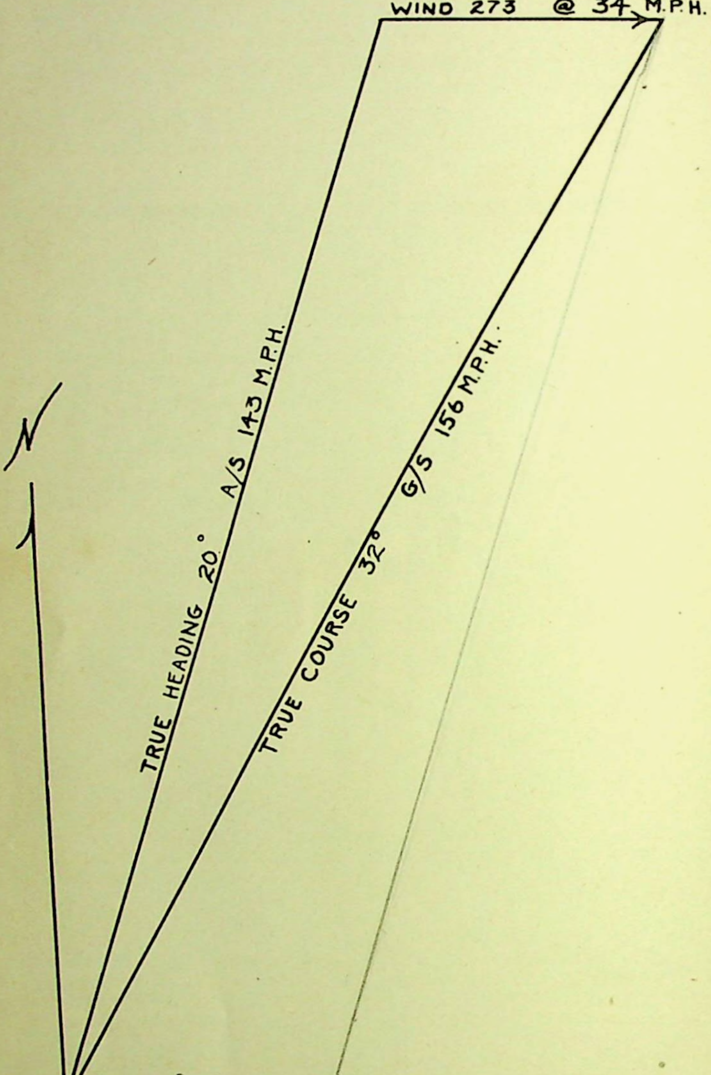


Fig. 22-B


WIND 273° @ 34 M.P.H.
N
TRUE HEADING 20° A/S 143 M.P.H.
TRUE COURSE 32° G/S 156 M.P.H.
273° @ 34

Example, problem type IV

(c) Determine the intersection point of the true airspeed, as represented by the curved lines, and the true heading, as represented by the radiating lines. Plot a small cross on the transparent plotting disk, to indicate this point.
(d) Rotate the azimuth ring until the cross is on the center line, above the grommet.
(e) Read the wind direction on the azimuth ring against the true index, and the wind velocity on the vertical scale between the grommet and the cross.

Example: Given: True course 32 degrees, ground speed 156 m.p.h., true heading 20 degrees and true airspeed 143 miles per hour. Find: Wind direction and velocity.
(a) Set the true course, 32 degrees, at the true index.
(b) Set the grommet over ground speed, 156 miles per hour.
(c) Plot a cross at the intersection of the 143 m.p.h. air speed circle and the radiating line representing the given heading of 20 degrees. (Heading 12 degrees left of course.) See Fig. 22-A, Page 37 .)
(d) Rotate the azimuth ring until the cross is on the center line above the grommet.
(e) Read the wind direction, 273 degrees, against the true index, and the wind force, 34 m.p.h., on the vertical scale between the cross and the grommet. (See Fig. 22-B, Page 37 .)

Examples for practice:

68. Given a true heading of 203 degrees, true airspeed of 160 knots, true course 210 degrees and ground speed 160 knots. What is the wind direction and velocity?
69. Given a true heading of 315 degrees, true airspeed 126 m.p.h., true course 311 degrees and ground speed 126 m.p.h. Find wind direction and velocity.
70. The true heading is 100 degrees, true airspeed 150 knots, true course 93 degrees and ground speed 132 knots. What is the wind direction and velocity?
71. With a true heading of 180 degrees, true airspeed 140 knots, true course 190 degrees and ground speed 160 knots, what is the wind direction and velocity?

DRIFT PROBLEMS.

Double drift is the name given a method of determining wind direction and velocity. The procedure consists of flying 45 degrees to the right and left of the on-course true heading and reading the drift on each leg. As with vector problems, the E-6B computer simplifies the graphic solution. Knowing the wind, true course and ground speed may also be determined.

Problem Type I: Double Drift.
(a) Set the true airspeed under the grommet.
(b) Set the on-course true heading opposite the true index. Draw a true course (track) line over the radiating line that represents the amount of drift to the left or right of the on-course heading.
(c) Rotate the azimuth ring so that the on-course true heading is opposite the 45 degree mark on the left end of the variation-drift scale. The right leg true heading will now be read opposite the true index.
(d) Draw a course line along the radiating line representing the amount of drift, right or left, of the right leg heading and crossing drift line number one.
(e) Rotate the azimuth ring so that the on-course true heading is

opposite the 45 degree mark on the right side of the variation-drift scale. The left leg true heading will now be read opposite the true index.

(f) Draw the true course over the radiating line representing the amount of drift to the left or right of the left leg heading, and crossing drift lines 1 and 2. If the intersection of the three lines forms a triangle, place a dot in the center to use for the head of the wind arrow.

(g) Rotate the azimuth ring so that the wind arrow lies on the center line and below the grommet. Read the wind force from the center line scale and the wind direction at the true index.

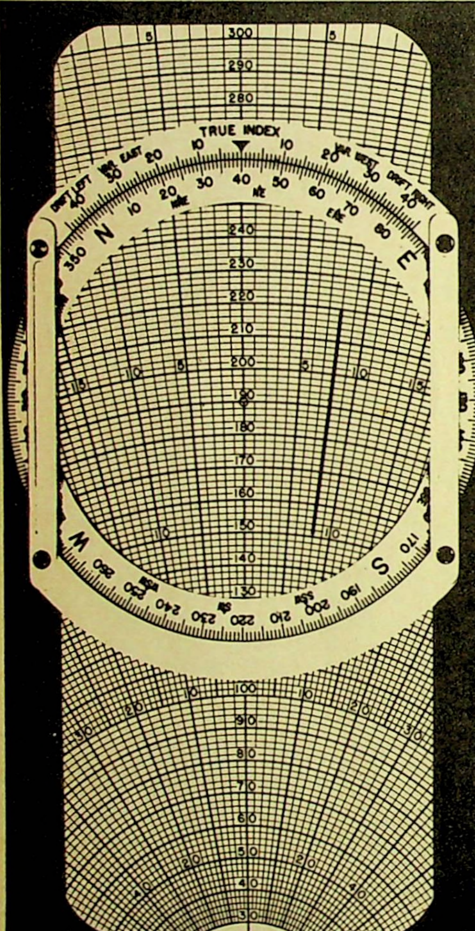


Fig. 23-A

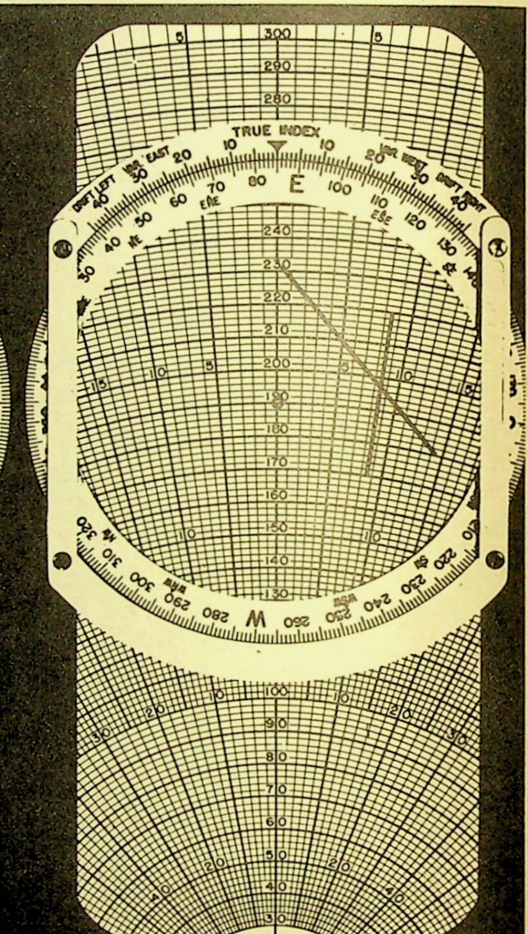


Fig. 23-B

DRIFT PROBLEMS

Note: Knowing true heading, true airspeed and wind direction and velocity, true course and ground speed can be determined. (See Problem Type I, Page 29.)

Example: At the navigator's request, the pilot flies a double drift; true airspeed 190 knots and on-course true heading 40 degrees. The navigator obtains the drift readings as follows: on-course drift 8 degrees right; right leg drift 8½ degrees right; left leg drift 1 degree right. What is the wind direction and force, the true course and ground speed?

(a) Set 190 true airspeed under the grommet.
(b) Set 40 degrees, on-course true heading, opposite the true index.

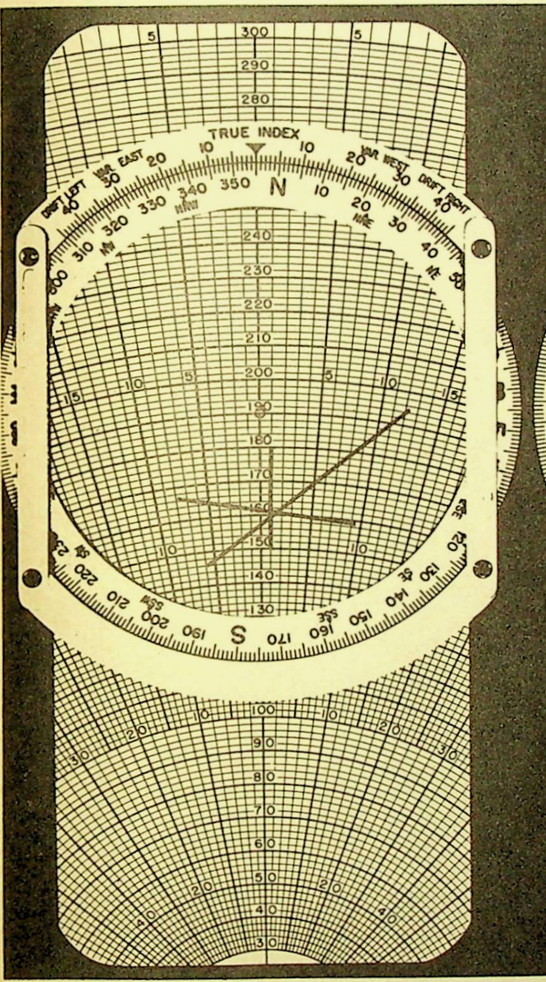


Fig. 23-C

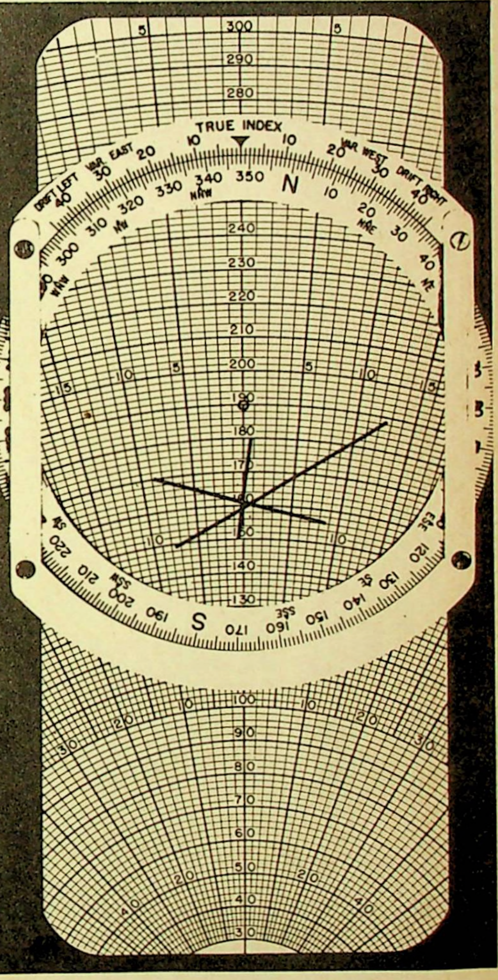


Fig. 23-D

Draw a line over the radiating line 8 degrees to the right of the center line. (8 degrees right drift) (See Fig. 23-A, Page 40.)

(c) Rotate the azimuth ring so that 40 degrees (on-course true heading) is opposite the 45 degree mark on the left side of the variation-drift scale. Read right leg true heading, 85 degrees, opposite the true index.

(d) Draw a line over the radiating line 8½ degrees to the right of the center line (drift 8½ degrees right) and crossing drift line number 1. (See Fig. 23-B, Page 40.)

(e) Rotate the azimuth ring so that 40 degrees is opposite the 45 degree mark on the right side of the variation-drift scale. Read left leg true heading, 355 degrees, opposite the true index.

(f) Draw a line over the radiating line 1 degree to the right of the center line. (Drift 1 degree right.) Cross this drift line with drift lines 1 and 2. (See Fig. 23-C, Page 41.)

(g) Rotate the azimuth ring so that the center of the wind triangle lies on the center line and below the grommet. Read the wind force, 30 knots, on the center line scale, and the wind direction, 348 degrees, opposite the true index. (See Fig. 23-D, Page 41.)

(h) Knowing true heading, true airspeed and wind, the true course, 47½ degrees, and ground speed, 173 knots, may be determined. (See Problem Type I, Page 29.)

Examples for practice.

72. Flying a double drift problem with true airspeed of 138 m.p.h. and on-course true heading of 10 degrees, the following drift readings are recorded: on-course drift 9 degrees right; right leg drift 5 degrees right; and left leg drift 8 degrees right. What is the wind direction and velocity?

73. A navigator records the following information on a double drift problem; on-course true heading 267 degrees, true airspeed 175 knots, on-course drift 4 degrees left, right leg drift 7 degrees right, and left leg drift 11 degrees left. What is wind direction and velocity?

Problem Type II: Drift on two headings.

As the wind force and the wind direction can be obtained whenever two or more headings and drift readings are known, it is not always necessary to fly a double drift. For example: after changing course, two headings are known, and if drift readings have been taken, the wind can be determined.

(a) Set the true airspeed under the grommet.

(b) Set the first true heading against the true index and draw a line over the radiating line to the right or left of the center line, as determined by the amount of drift.

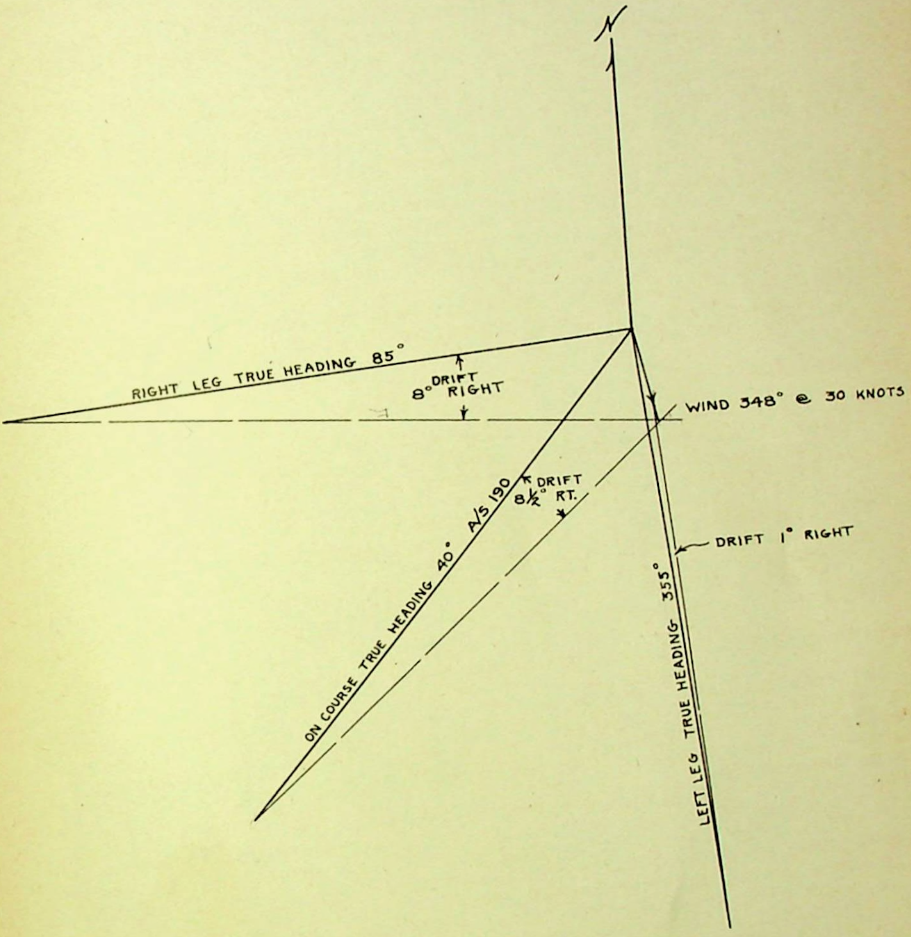
(c) Set the second true heading against the true index and draw a line over the radiating line representing the drift on this heading, and intersecting drift line number 1.

(d) Rotate the azimuth ring so that the intersection of the two drift lines is on the center line and below the grommet. Read the wind direction opposite the true index and wind velocity from the center line scale.

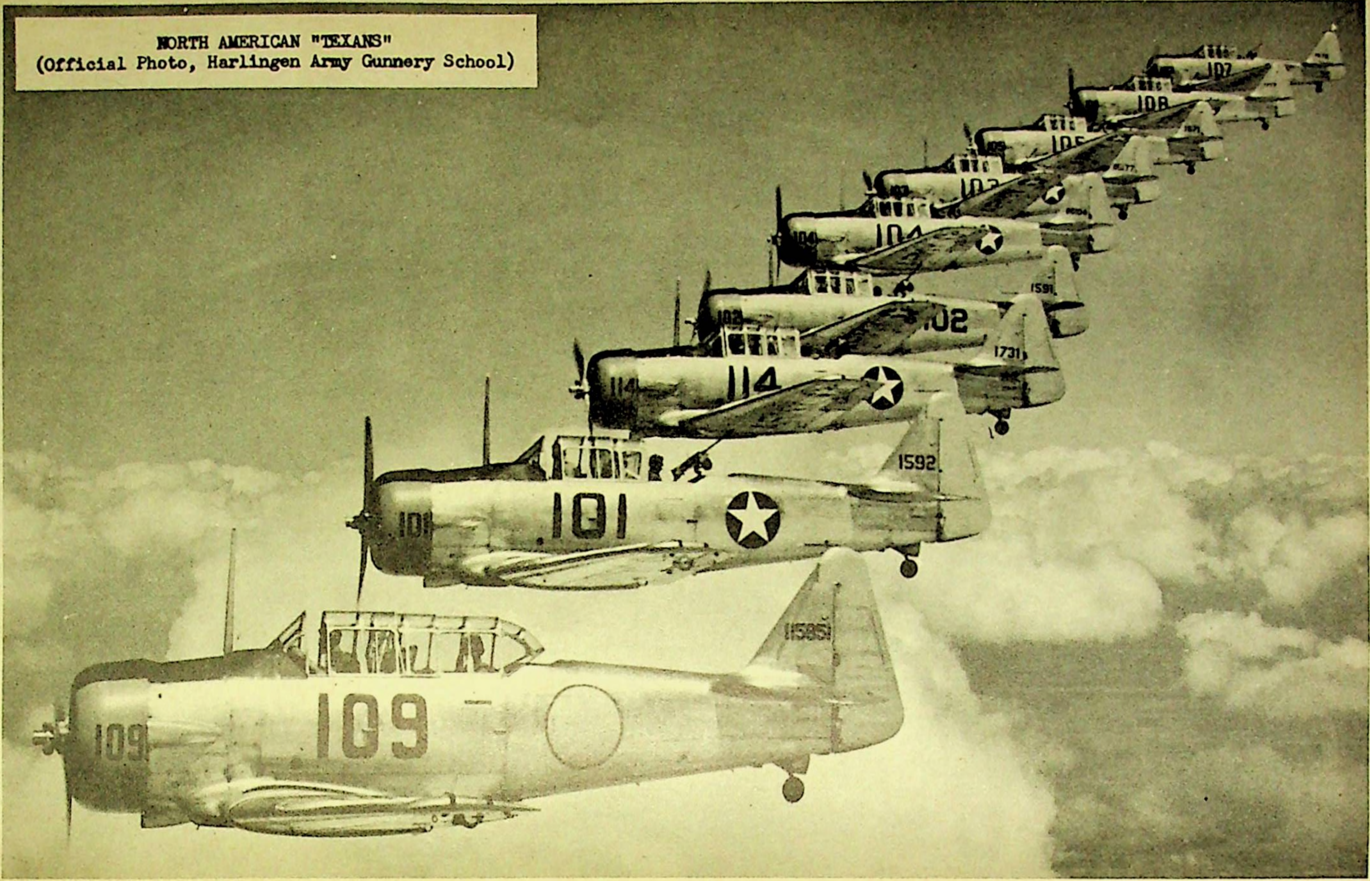
Example: Before making a turn from a true heading of 65 degrees, the pilot reads a drift of 10 degrees left. A turn is then made to a true heading of 140 degrees and a drift of 5 degrees right is read. True airspeed is 190 m.p.h. What is the wind direction and force?

(a) Set the true airspeed, 190 m.p.h. beneath the grommet.

(b) Set the first true heading, 65 degrees, against the true index


N
RIGHT LEG TRUE HEADING 85°
8° DRIFT RIGHT
WIND 348° @ 30 KNOTS
ON COURSE TRUE HEADING 40° A/S 190
DRIFT 8½° RT.
DRIFT 1° RIGHT
LEFT LEG TRUE HEADING 355°

Graphic solution of Double Drift problem.



NORTH AMERICAN "TEXANS"
(Official Photo, Harlingen Army Gunnery School)

and draw a line over the radiating line 10 degrees to the left of the center line. (10 degrees left drift.) (See Fig. 24-A.)

(c) Set the second true heading, 140 degrees, against the true index and draw a line over the radiating line 5 degrees to the right of the center line, and crossing drift line number 1. (5 degrees right drift.) (See Fig. 24-B, Page 46.)

(d) Rotate the azimuth ring so that the intersection of the two drift lines is on the center line and below the grommet. Read wind direction, 118 degrees, opposite the true index, and the wind velocity, 37 m.p.h. on the center line scale. (See Fig. 24-C, Page 46.)

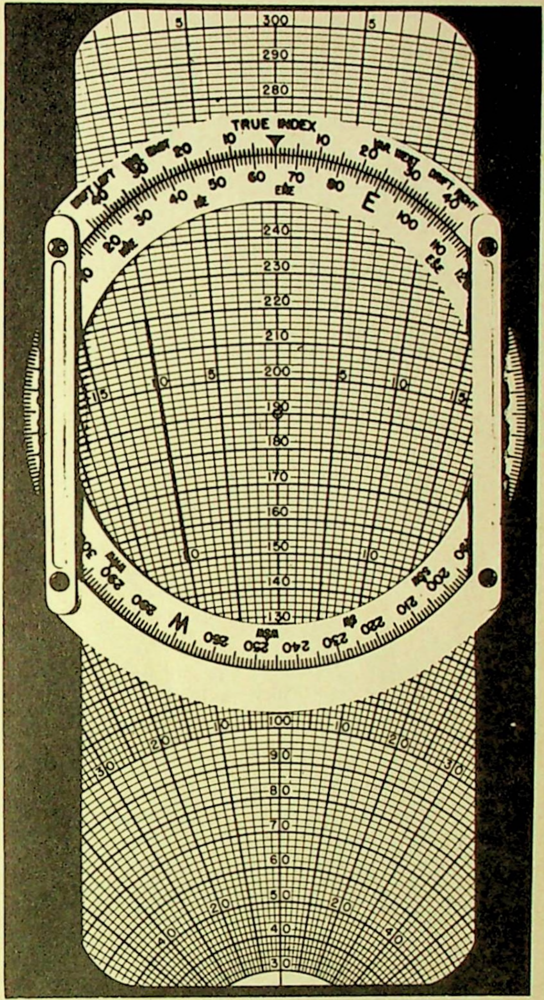


Fig. 24-A

Examples for practice:

74. After making a turn from a true heading of 38 degrees to a true heading of 113 degrees, the following drift readings are recorded: first heading, drift 4 degrees right; second heading, drift 1 degree left. The true airspeed is 143 miles per hour. What is the wind direction and velocity?

75. On a true heading of 357 degrees, a drift of 15 degrees left is read. Later, on a true heading of 18 degrees, a drift of 13 left is recorded. The true airspeed is 169 knots. What is the wind direction and velocity?

76. After making a turn from a true heading of 186 degrees to a true heading of 273 degrees, the following drift readings are recorded: first heading, 8 degrees right; second heading 5

degrees right. The true airspeed is 156 miles per hour. What is the wind direction and velocity?

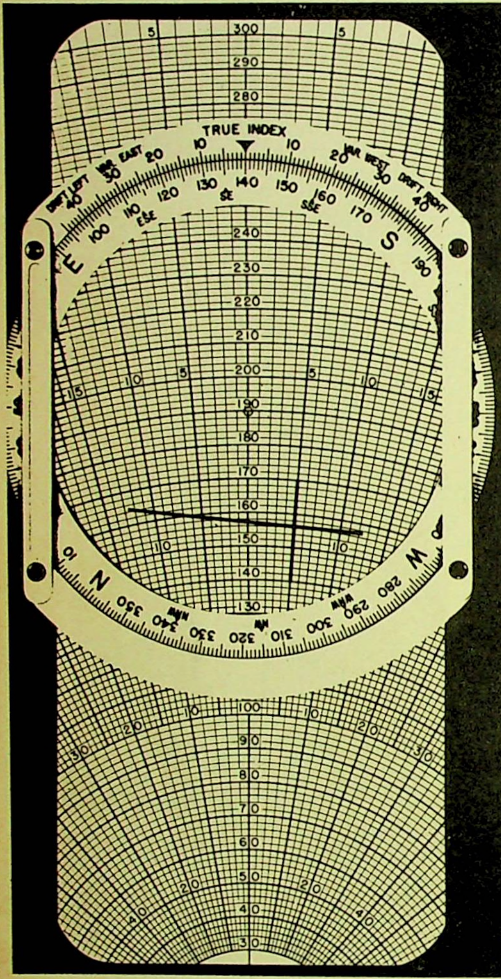


Fig. 24-B.

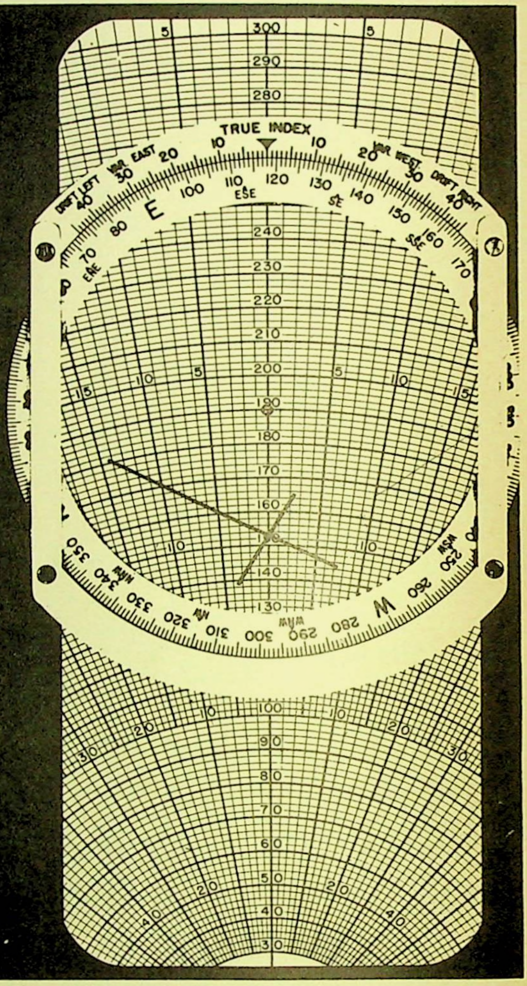


Fig. 24-C.

RADIUS OF ACTION TO THE SAME BASE.

Radius of action of an aircraft is the greatest distance that it may fly along a certain course under known conditions of airspeed, wind, and fuel consumption; and return to the starting point. The problem consists of determining the ground speeds out and back, the headings out and back, and the solution of the radius of action formula to find time of turn and the radius of action. All phases of this problem can be solved on the E-6B computer.

RADIUS OF ACTION TO THE SAME BASE

Problem Type: Radius of Action to the Same Base.

(a) Set the wind direction against the true index and draw the wind, at the given velocity, down to the grommet.

(b) Set the true course out against the true index, and the true airspeed under the tail of the wind arrow.

(c) Read the ground speed out under the grommet. The radiating line through the tail of the wind line represents the true heading. Determine the angular distance from the center line (true course) and apply to course to obtain true heading.

(d) Set true course back (true course out plus or minus 180 degrees) against the true index, and the tail of the wind arrow on true airspeed.

(e) Read ground speed back under the grommet. Determine true heading back from the radiating line through the tail of the wind arrow.

(f) Solve for time of turn and radius of action with the slide rule face of the computer as previously explained on page 22.

Example: A plane takes off to patrol a true course of 70 degrees at a true airspeed of 156 knots. The plane carries enough fuel for 5 hours aside from the required reserve. The wind is from 345 degrees at 25 knots. Required: ground speed out and back, true heading out and back, radius of action and time to turn.

(a) Set wind direction, 345 degrees, against the true index and draw the wind line 25 miles down to the grommet. (See Fig. 25-A.)

(b) Set the true course, 70 degrees, opposite the true index, and the tail of the wind arrow on 156 true airspeed.

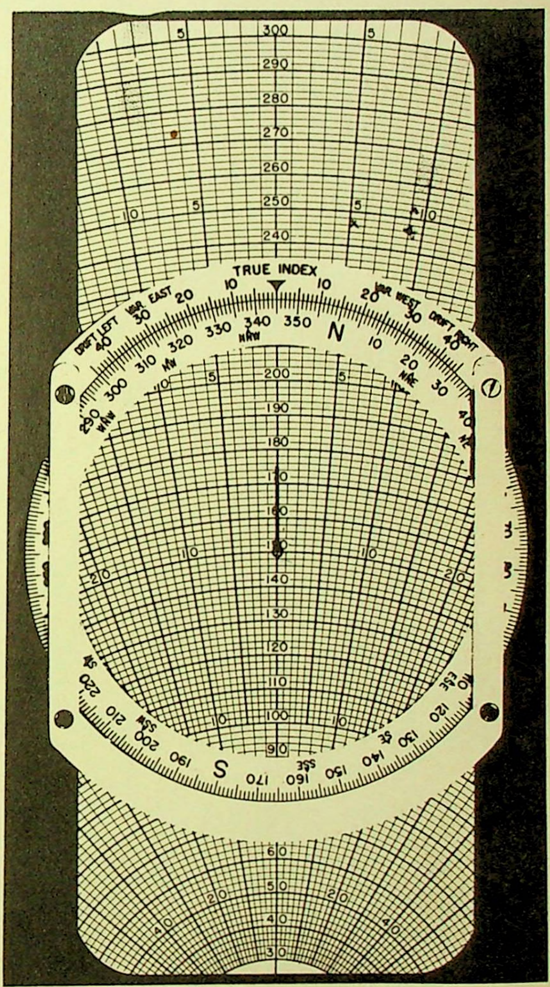


Fig. 25-A

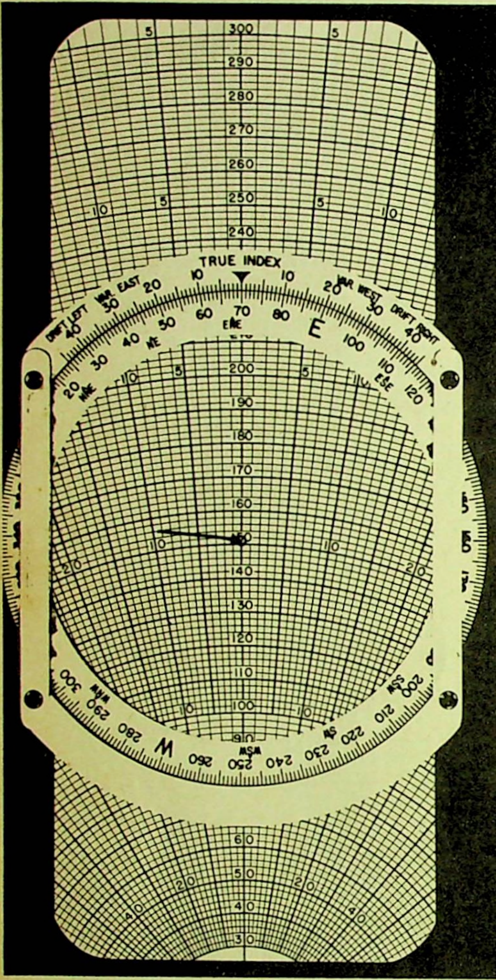


Fig. 25-B

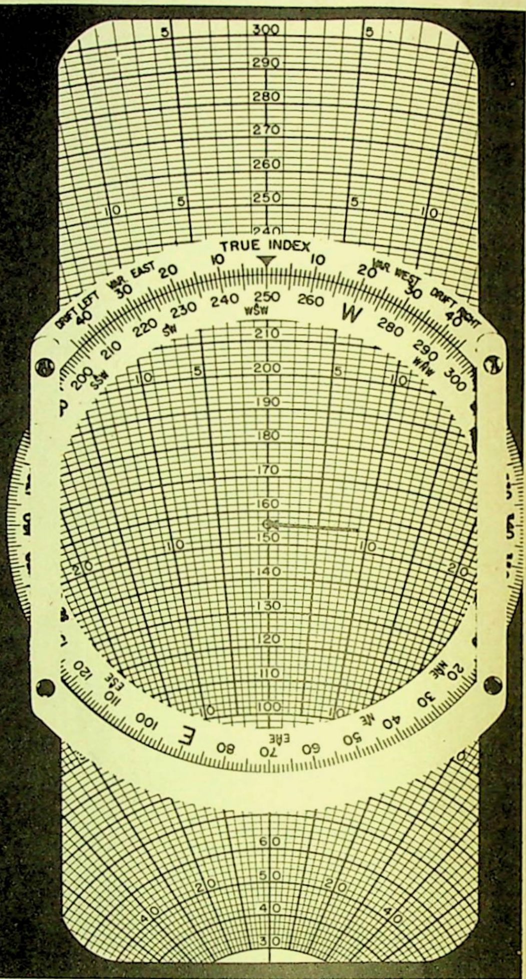


Fig. 25-C

(c) Read the ground speed out, 151 knots, under the grommet. From the radiating line through the tail of the wind line, determine heading out of 60½ degrees. (Heading 9½ degrees left of course.) (See Fig. 25-B.)

(d) Set the true course back, 250 degrees, against the true index, and the tail of the wind arrow on 156 knots true airspeed.

(e) Read the ground speed back, 156 knots, under the grommet. From the radiating line through the tail of the wind arrow determine true heading back of 259 degrees. (Heading 9 degrees right of course.) (See Fig. 25-C.)

(f) Solve the radius of action formula on the circular slide rule to find time to turn, 2:33, and radius of action 385 nautical miles.

Examples for practice:

77. A pilot intends to patrol a true course of 233 degrees at a true airspeed of 130 m.p.h. The wind is 287 degrees at 30 m.p.h. and the plane carries fuel for 3½ hours, not counting the reserve. Find ground speeds out and back, true headings out and back, time to turn and radius of action.
78. Given true course out 178 degrees, true airspeed 172 knots, wind from 86 degrees at 22 knots and net fuel hours 2:45. Find ground speeds out and back, true headings out and back, radius of action and time to turn.
79. A plane takes off to patrol a true course of 330 degrees with a true airspeed of 110 m.p.h. Wind from 20 degrees at 20 m.p.h. and net fuel hours 6. What is the ground speed out and back, true heading out and back, radius of action and time to turn?

OFF-COURSE PROBLEMS.

The solution of an off-course problem on the E-6B computer, while not exact, will seldom introduce an error of over one degree or one mile. Since no serious loss of accuracy will result, the saving in time will compensate for this slight disadvantage.

The designation of points is as follows: "A" is the point of departure, "B" is the destination and "X" the off-course position.

Problem Type I: Off course with estimated wind.

(a) Set the true course, "A" to "B" against the true index. Place the rectangular grid under the plotting disk. Draw a horizontal line to the right or left of the grommet the number of miles the plane is off-course.

(b) Reverse the grid and set the distance flown under the grommet. From the radiating line through the end of the horizontal line determine drift and apply to true course "A" to "B" to obtain true course "A" to "X".

(c) Set the distance "X" to "B" under the grommet (distance "A" to "B" minus distance "A" to "X"). From the radiating line through the horizontal line determine drift and apply, in opposite direction, to true course "A" to "B" to obtain true course "X" to "B". (During steps (a), (b), and (c) the true course "A" to "B" must remain opposite the true index.)

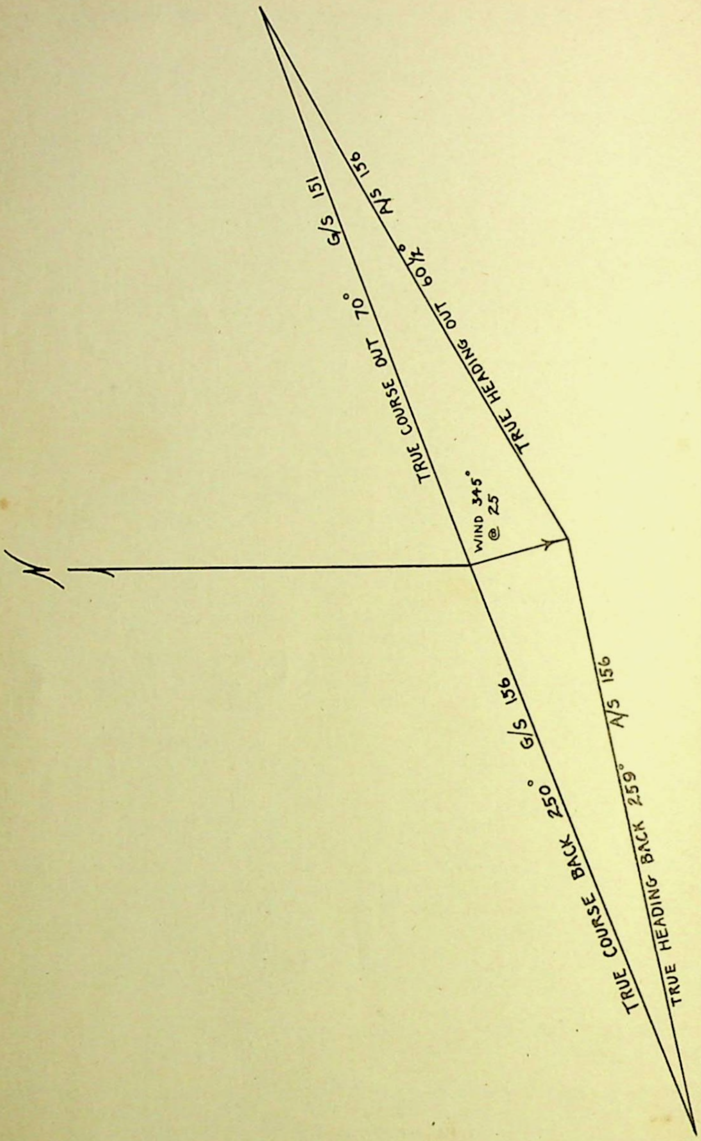
(d) With the estimated wind, true course "A" to "B" and the true airspeed, solve vector triangle to find true heading "A" to "X". (This will be the same as true heading "A" to "B".)

(e) With true course, true heading, true airspeed and ground speed, "A" to "X", solve vector triangle for new wind.

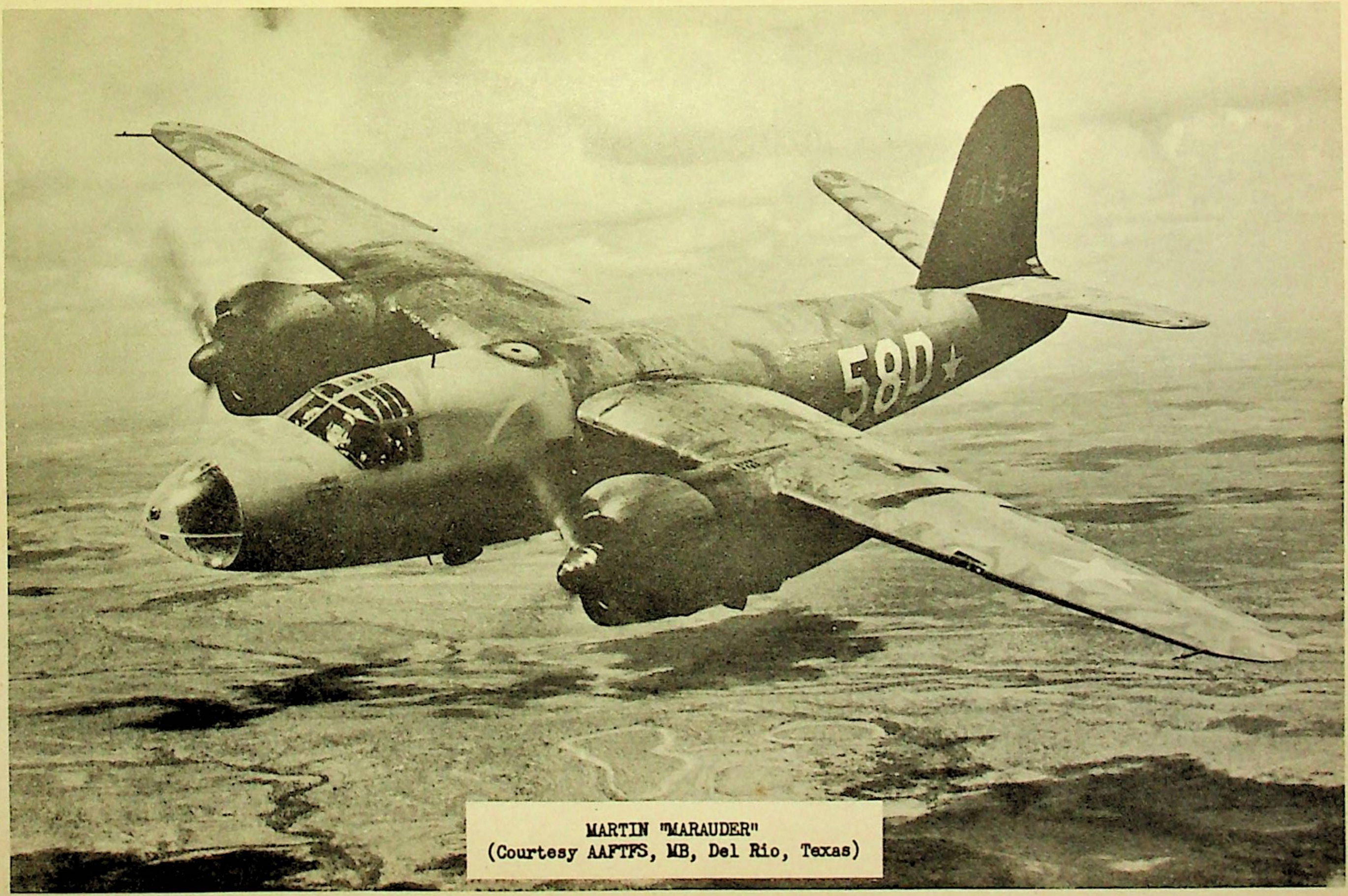
(f) With the new wind, true course "X" to "B" and true airspeed solve vector triangle for true heading and ground speed, "X" to "B".

(g) Knowing distance and ground speed "X" to "B", use circular slide rule to solve for time.

Note: As the above problem type depends on finding the true course "A" to "X" and the true heading "A" to "X", to determine the new wind, any off-course problem can be solved in the same manner. For instance, in an off-course problem with no estimated wind, the true course "A" to "B" is the true heading "A" to "X", as the pilot actually heads the plane along the original true course. This simplifies the problem since step (d) may be dropped from the solution, with the true heading already known. In any type of problem where the off-course position does not


N
TRUE COURSE OUT 70° G/S 151
TRUE HEADING OUT 60½° A/S 156
WIND 345° @ 25
TRUE COURSE BACK 250° G/S 156
TRUE HEADING BACK 259° A/S 156

Graphic solution, Radius of Action problem.



MARTIN "MARAUDER"
(Courtesy AAFTFS, MB, Del Rio, Texas)

fall on the one-half or even hour, the procedure is exactly the same. Ground speed can be determined by the solution of a speed-time-distance problem and the triangles of velocity solved. (See page 14, Problem Type I.) In actual flight the off-course point is usually not the change-course point since the pilot requires a few minutes for the solution of the problem. The pilot can estimate closely enough the few extra miles flown during the time it will take to work the problem, so that "X" will actually be the turning point. The procedure for all types of off-course problems will remain the same, and the method of solution above can always be followed.

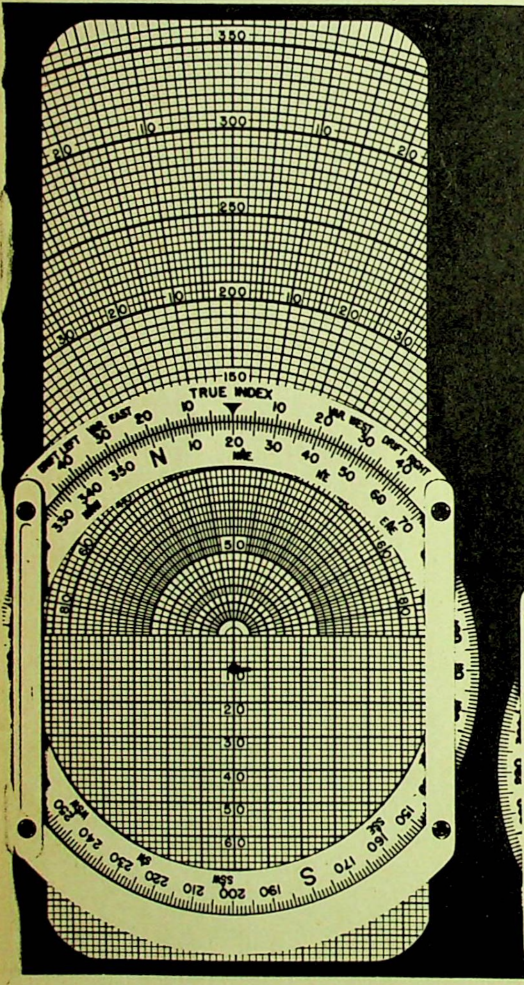


Fig. 26-A

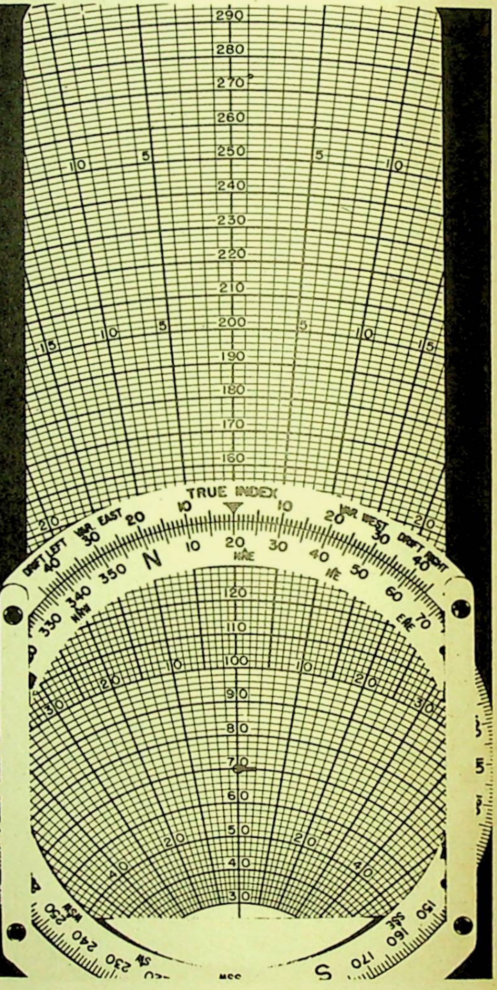


Fig. 26-B

Example: Off course with estimated wind.

Given: True course "A" to "B", 20 degrees, distance 200 miles. The wind is from 340 degrees at 24 miles per hour. True airspeed is 152 miles per hour. At the end of ½ hour the pilot finds himself 5 miles to the right of the original intended true course and 70 miles from "A". Find the true course, ground speed, true heading "A" to "X", and the new wind. From "X" to "B" determine distance, ground speed, true heading, true course, and time.

(a) Set the true course "A" to "B", 20 degrees, opposite the true index. Place the rectangular grid under the plotting disk and draw a horizontal line out from the grommet 5 miles to the

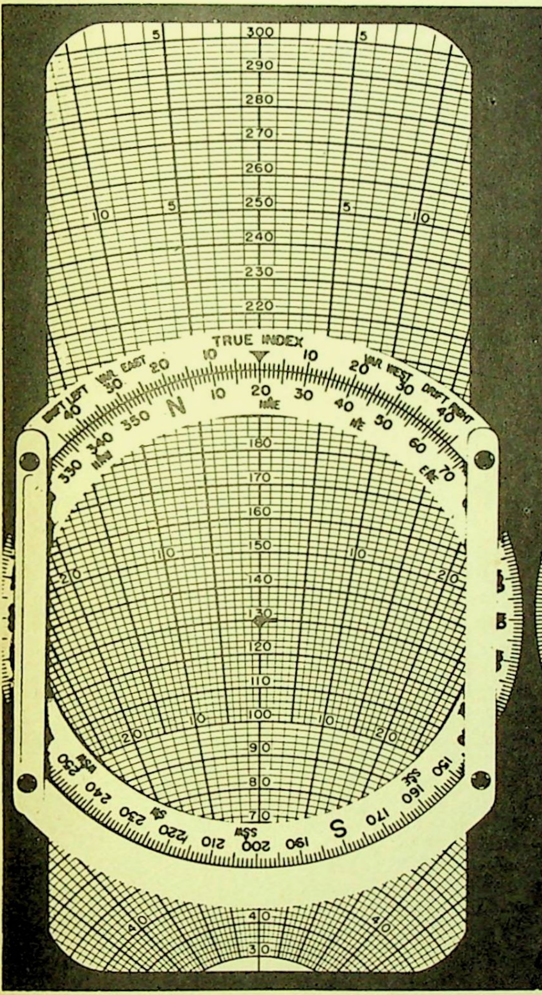


Fig. 26-C

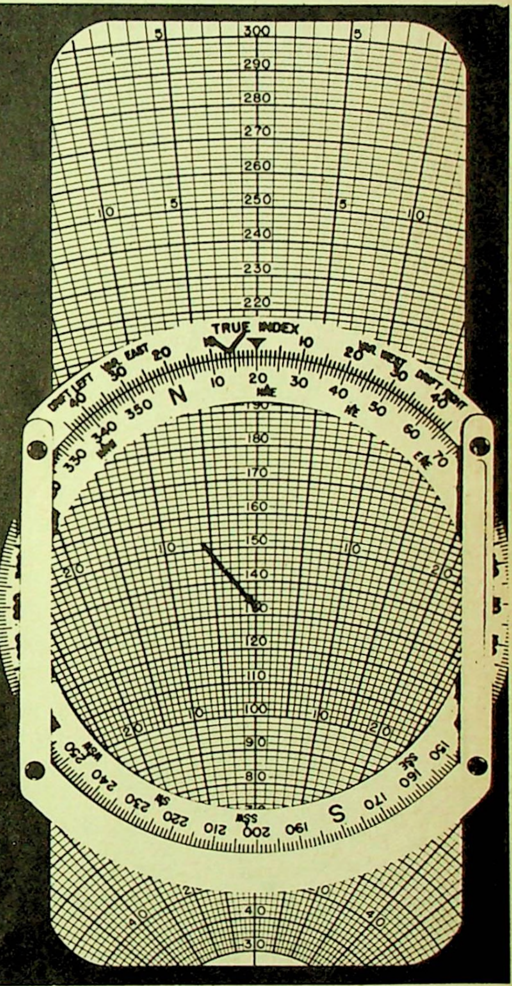


Fig. 26-D

right. (See Fig. 26-A, Page 52.)

(b) Reverse the grid and set the distance flown, 70 miles, under the grommet. From the radiating line through the end of the horizontal line read the drift, 4 degrees right, and apply to the true course "A" to "B", 20 degrees to obtain the true course "A" to "X" 24 degrees. (See Fig. 26-B, Page 52.)

(c) Set the distance "X" to "B", 130 miles, under the grommet. (Distance "A" to "B", 200 miles, minus the distance "A" to "X", 70 miles.) From the radiating line through the end of the horizontal line, read the drift, 2 degrees right, and apply in the opposite direction to true course "A" to "B", 20 degrees to obtain true course "X" to "B", 18 degrees. (See Fig.26-C,Page 53)

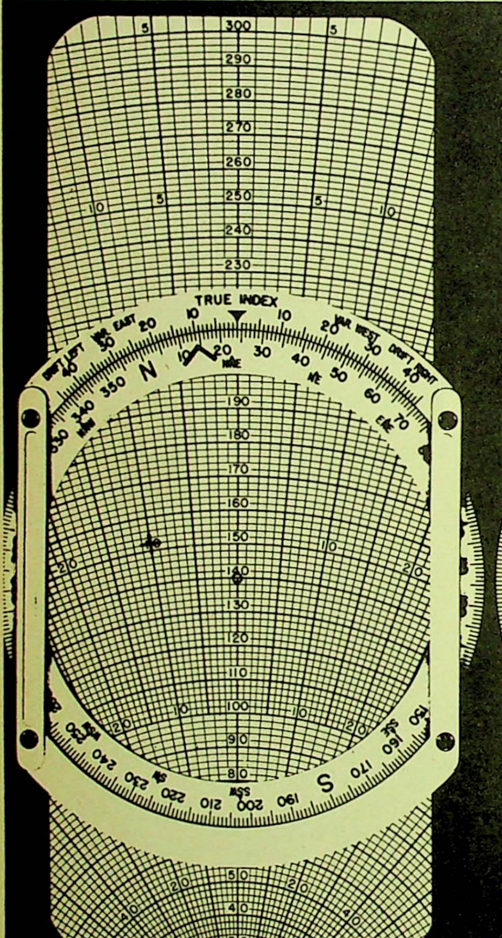


Fig. 26-E

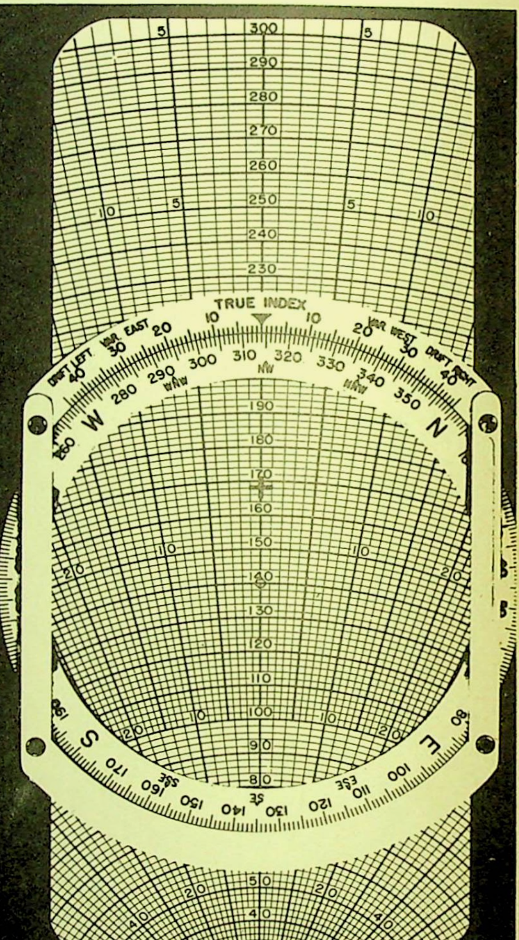


Fig. 26-F

(d) With the estimated wind, 340 degrees at 24 miles per hour, the true course "A" to "B", 20 degrees, and the true air speed, 152 miles per hour, solve a vector triangle for the true heading "A" to "X", 14 degrees. (See Fig. 26-D, Page 53.) (Reference, Problem Type II, Page 33.)

(e) With the true course "A" to "X", 24 degrees, true heading "A" to "X", 14 degrees, true airspeed, 152 miles per hour, and ground speed of 140 miles per hour, (70 miles in ½ hour gives a ground speed of 140 miles per hour) solve a vector triangle for the new wind, 314 degrees at 28 miles per hour. (See Figs. 26-E and 26-F, Page 54.) (Reference, Problem Type IV, Page 37.)

(f) With the new wind, 314 degrees at 28 miles per hour, the true course "X" to "B", 18 degrees, and the true airspeed 152 miles

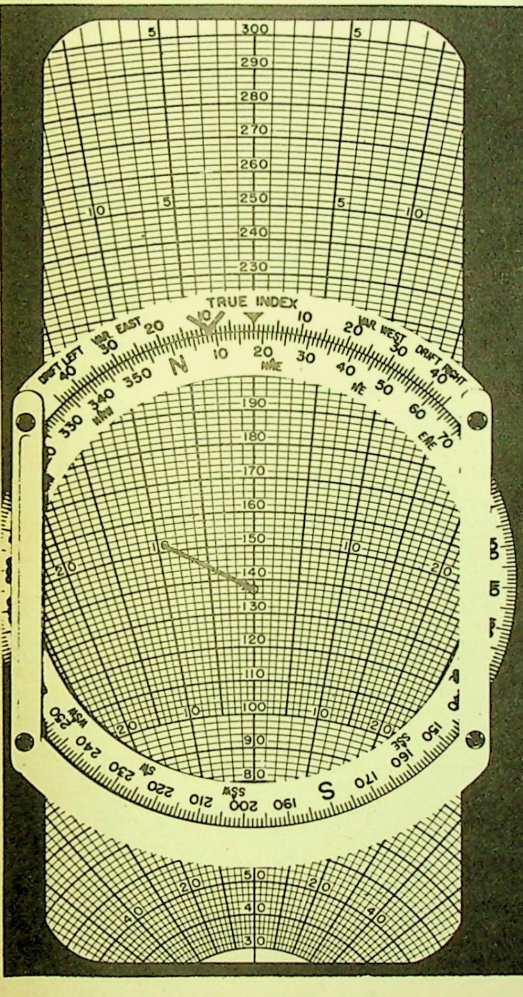


Fig. 26-G

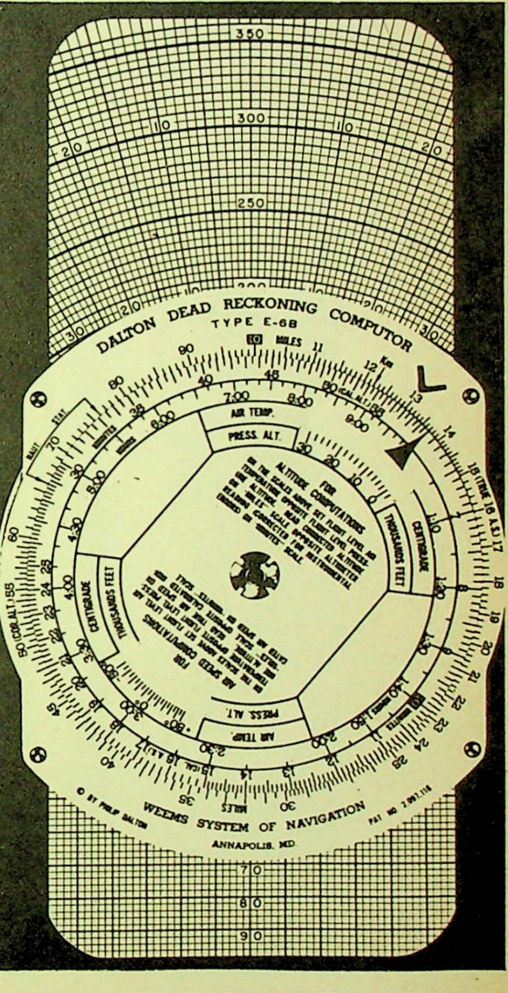


Fig. 26-H

per hour, solve a vector triangle for the ground speed "X" to "B", 137 miles per hour, and the true heading "X" to "B", 8½ degrees. (See Fig. 26-G, Page 55.)

(g) With the distance "X" to "B", 130 miles, and the ground speed of 137 miles per hour, find the time from "X" to "B", 57 minutes, on the circular slide rule. (See Fig. 26-H, Page 55.)

Examples for practice:

80. Given a true course "A" to "B" of 265 degrees, distance "A" to "B", 300 miles. The estimated wind is from 15 degrees at 34 miles per hour and the true airspeed is 138 miles per hour. At the end of one hour, the pilot finds himself 8 miles to the right of the intended true course and 150 miles from "A". Required: true heading "A" to "B", true course "A" to "X", true course "X" to "B", the new wind, true heading, ground speed, distance and time, "X" to "B".

81. Given a true course "A" to "B" of 193 degrees, distance "A" to "B" 185 miles. The true airspeed is 130 miles per hour and the estimated wind is from 105 degrees at 32 miles per hour. After ½ hour the pilot is 6 miles to the left of the intended true course and 72 miles from "A". Required: true course "A" to "X", true heading "A" to "X", ground speed "A" to "X", new wind, true course

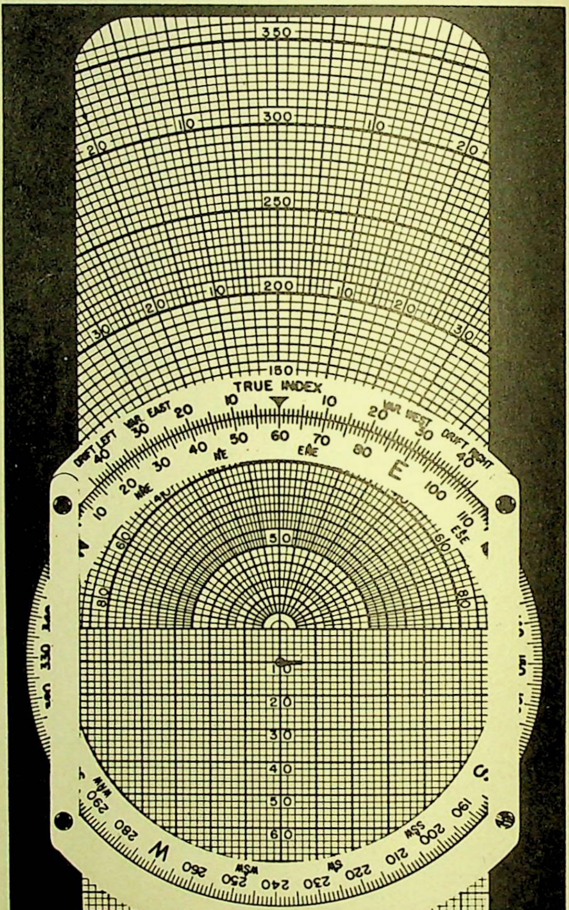
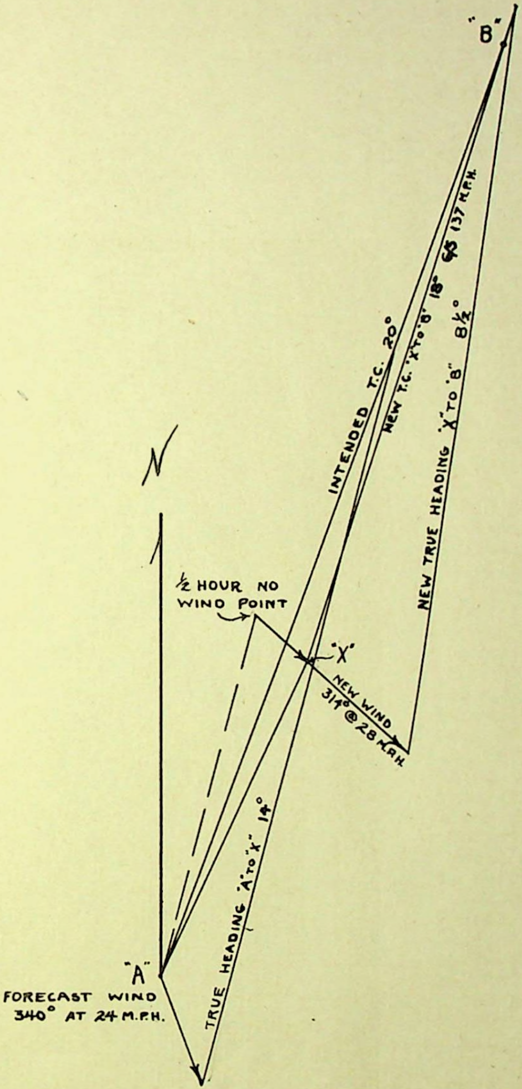
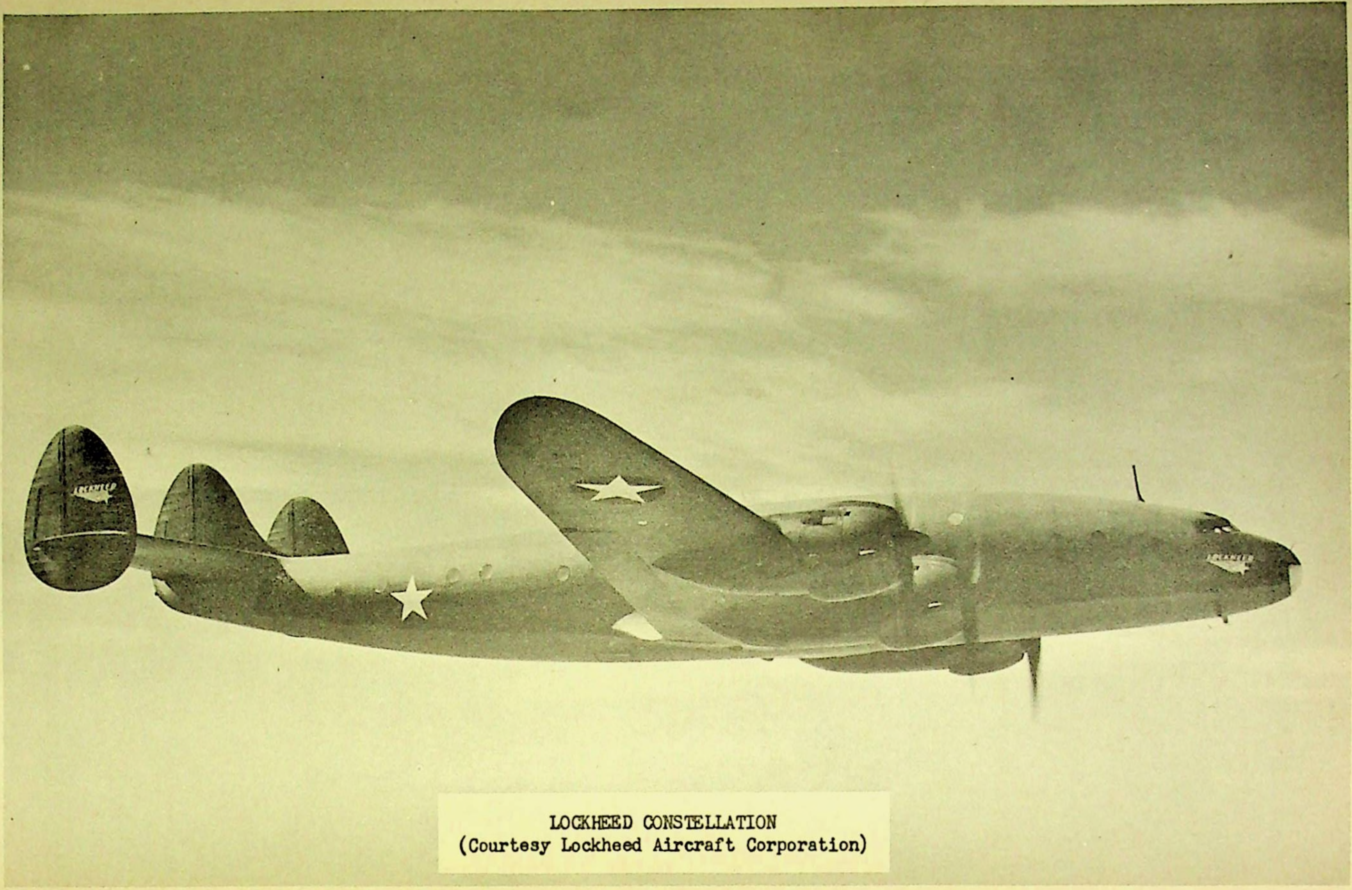


Fig. 27-A


"B"
N
INTENDED T.C. 20°
NEW T.C. "X" TO "B" 18° GS 137 M.P.H.
NEW TRUE HEADING "X" TO "B" 8½°
½ HOUR NO WIND POINT
"X"
NEW WIND 314° @ 28 M.P.H.
TRUE HEADING "A" TO "X" 14°
"A"
FORECAST WIND 340° AT 24 M.P.H.

Graphic Solution, Off-Course problem.



LOCKHEED CONSTELLATION
(Courtesy Lockheed Aircraft Corporation)

"X" to "B", true heading "X" to "B", ground speed, distance and time "X" to "B".

82. Given true course "A" to "B" of 279 degrees, distance 195 nautical miles, true airspeed 102 knots and no estimated wind. At the end of one hour the pilot finds himself 8 miles to the right of the original true course and 112 miles from "A". Required: true heading "A" to "X", true course "A" to "X", ground speed "A" to "X", and the wind direction and velocity. From "X" to "B" determine the true heading, ground speed, distance and time.

Problem Type II: After drifting from the intended course, to correct

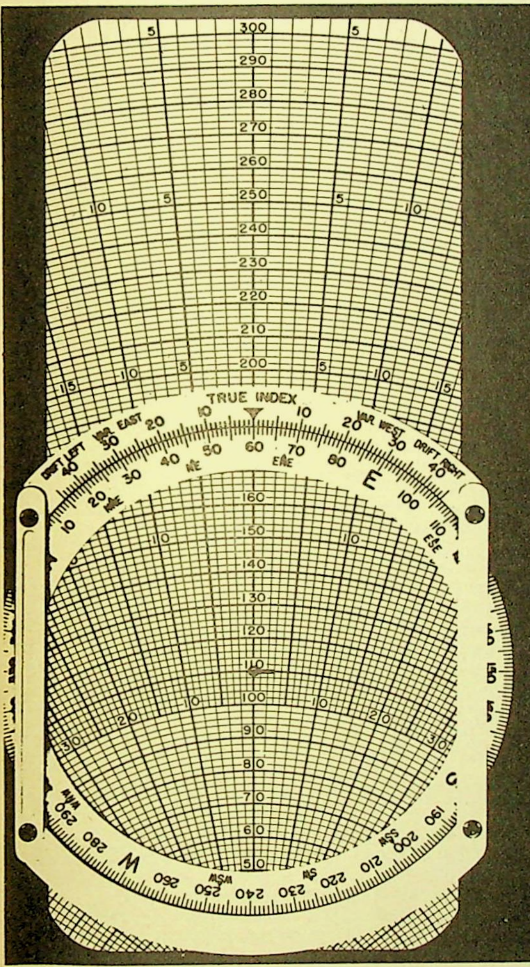


Fig. 27-B

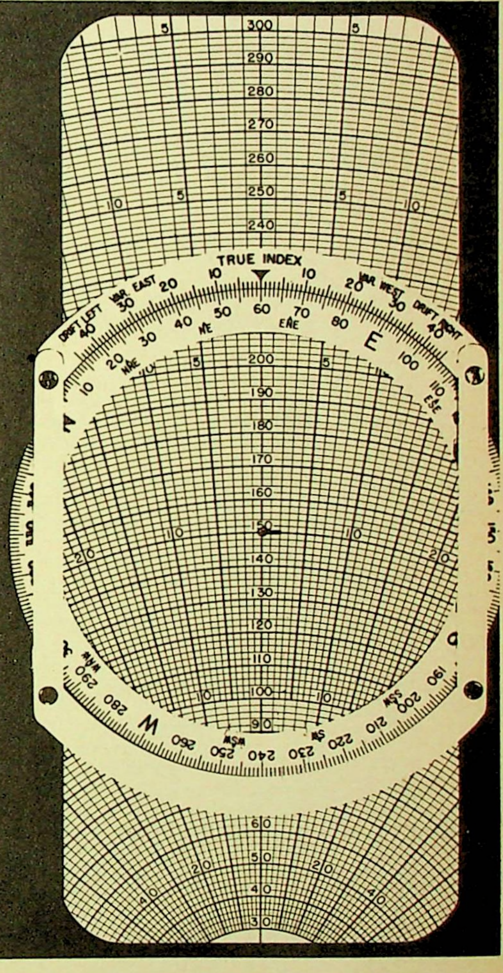


Fig. 27-C

the heading to get to destination.

(a) Set the true heading the pilot has been flying, opposite the true index. Place the rectangular grid under the plotting disk and draw a horizontal line to the right or left of the grommet the number of miles the plane is off course.

(b) Reverse the grid and set the distance flown under the grommet. From the radiating line through the end of the horizontal line, determine the drift. Set the distance to go (distance "A" to "B" minus the distance flown) under the grommet and again note the drift.

(c) Add the two drift readings and apply to the true heading in the opposite direction, to obtain true heading to destination.

Example: A pilot flying from town "A" to town "B", a distance of 260 miles, has been maintaining a true heading of 60 degrees. After some time he determines that he has drifted 6 miles to the right of his intended true course and is 110 miles from "A". What is the correct heading to get to destination?

(a) Set 60 degrees opposite the true index. Place the rectangular grid under the plotting disk and draw a horizontal line 6 miles to the right of the grommet. (See Fig. 27-A, Page 58.)

(b) Reverse the grid and set the distance flown, 110 miles, under the grommet. From the radiating line through the end of the horizontal line, determine drift, 3 degrees to the right. (See Fig. 27-B, Page 59.) Set the distance to go, 150 miles (260 miles total distance minus 110 miles flown) under the grommet. Read the drift, 2 degrees right. (See Fig. 27-C, Page 59.)

(c) Apply the total drift, 5 degrees, to the true heading, 60 degrees, in the opposite direction, to obtain the true heading to destination, 55 degrees.

Examples for practice:

83. A pilot flying between two check points 200 miles apart, and maintaining a true heading of 90 degrees, finds that he is 10 miles to the left of his course and 100 miles from his last check point. What is the true heading to the next check point?
84. A pilot finds himself 8 miles to the left of course after flying for 130 miles on a true heading of 267 degrees, between two towns 314 miles apart. What is the true heading to destination?

INTERCEPTION.

Interception of a moving ship is easily solved on the computer if the following information is known or can be determined: true course and speed of the ship to be intercepted; bearing and distance from the interceptor at the start of the problem. In addition, the true airspeed of the intercepting plane and the wind direction and velocity, must be known.

The required information:
True heading to interception.
Time of interception.
Ground speed.
True course to interception.

(a) Set ship's course at the true index and plot in a line upward from the grommet equal to the ship's speed in length. Label the end of this line "S".

(b) Set the wind direction opposite the true index. Reverse the grid and with the aid of the rectangular grid lines plot in the wind line from above down to point "S". (Arrow-head of wind line at point "S".) Label tail of wind line "W".

(c) Reverse grid so that original side is under the plotting disk. Set the bearing of ship from plane opposite the true index. Set the tail of the wind line (point "W") on true airspeed.

(d) The center line of the grid now represents the bearing of the ship from the plane. Under the grommet read rate of interception. Determine ground speed from speed circle passing through point "S".

(e) The radiating line passing through point "S" represents the direction of the course relative to the bearing of ship from plane, and the line through point "W" the direction of the true heading relative to the bearing. Determine the angular distance from the center line (bearing line) and apply to variation-drift scale. Read corresponding course and heading on compass rose. Note: the bearing of ship from plane, as set up in step (c), must be maintained in steps (d) and (e).

(f) Using the circular slide rule, the time of interception can be determined. Divide the distance between ship and plane at the start of the problem by the rate of interception, as found in step (d).

Example: A plane takes off to intercept a ship reported on a true course of 45 degrees at a speed of 22 knots. At time of take-off the ship bears 290 degrees from the plane and is 210 miles away. The true airspeed of the plane is 156 knots and the wind is from 350 degrees at 24 knots.

Required: Rate of interception.
True course to interception.
True heading to interception.
Ground speed.
Time.

(a) Set ship's course, 45 degrees, at the true index and plot in a line upward from the grommet 22 units, to represent ship's speed. Label the end of this line "S". (See Fig. 28-A, Page 62.)

(b) Set wind direction, 350 degrees, opposite the true index. Reverse the grid and with the aid of the rectangular grid plot in the wind at 24 knots from above down to point "S". (Arrow-head of wind at point "S".) Label end of wind line "W". (See Fig. 28-B, Page 62.)

(c) Reverse grid so that original side is under the plotting disk. Set bearing of ship from plane, 290 degrees, opposite the true index. Set tail of wind line, (point "W") on true airspeed of 156 knots.

(d) The center line of the grid now represents the bearing of the ship from the plane. Under the grommet read the rate of interception, 148 knots. Read the ground speed, 140 knots, from the speed circle passing through point "S". The radiating line passing through point "S" represents the direction of the course relative to the bearing of ship from plane. Read angular distance, 8 degrees right of center line, making the true course 298 degrees. The radiating line through point "W" represents the true heading, 15 degrees right, making the true heading 305 degrees. (See Fig. 28-C, Page 63.)

(e) Using the circular slide rule find time of interception, 1:25, by dividing the initial distance of 210 miles, by rate of interception, 148 knots.

Examples for practice:

85. A plane takes off to intercept a ship reported to be on a true course of 255 degrees at a speed of 30 knots. At the time of take-off the ship bears 30 degrees from the plane and is 200 miles away. The true airspeed of the plane is 130 knots and the wind is from 73 degrees at 30 knots. Required: rate of interception, true heading to interception, ground speed, true course

to interception, and time.

86. A plane takes off to intercept a ship reported to be on a true bearing of 185 degrees and 330 miles away. The ship's speed is 24 knots, on a course of 263 degrees. The plane's true airspeed is 144 knots and the wind is from 63 degrees at 22 knots. Required: rate of interception, true course to interception, ground speed, true heading to interception, and time.

87. A R.A.F. pilot takes off in a Supermarine to intercept a convoy reported on a true course of 358 degrees at a speed of 22 knots. At time of take off the convoy bears 265 degrees and 480 miles from the departure point of the plane. True airspeed of the Supermarine is 280 knots and the wind is from 30 degrees at

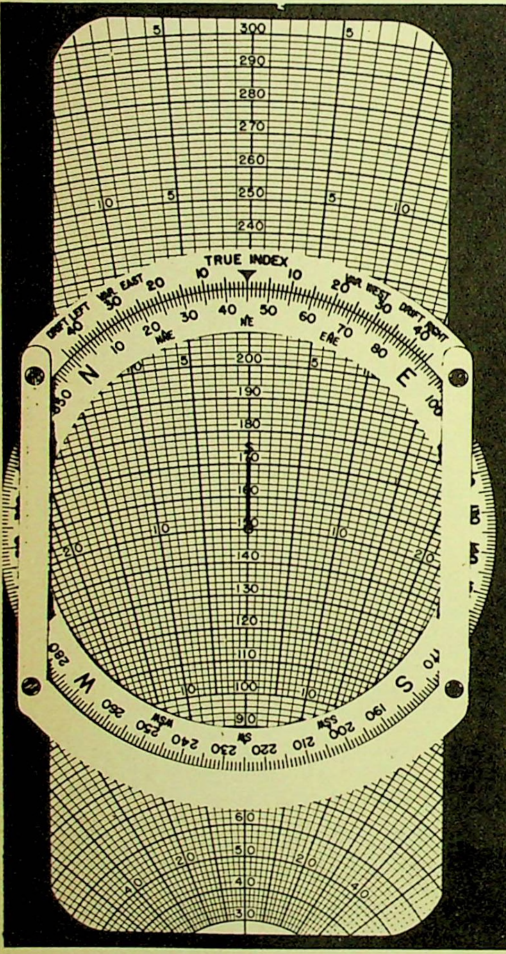


Fig. 28-A

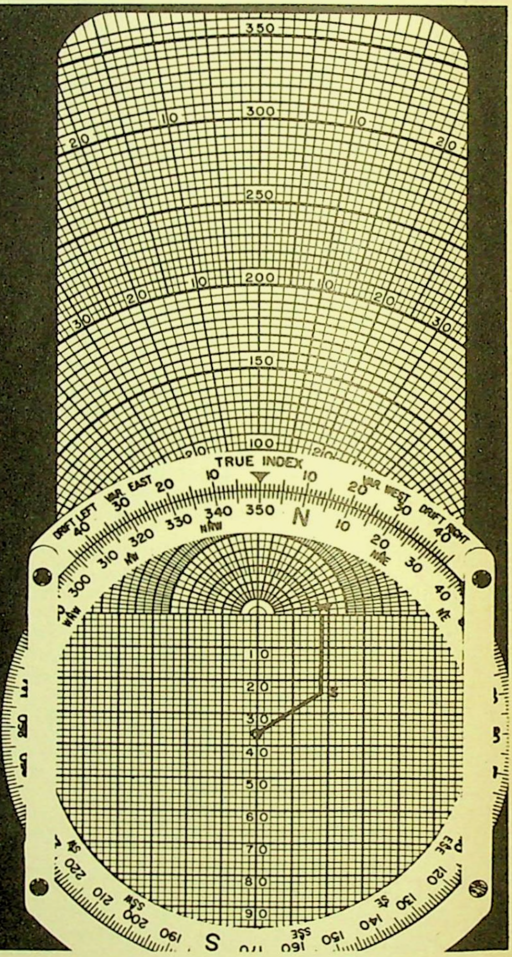


Fig. 28-B.

28 knots. Required: rate of interception, true course to interception, true heading to interception, ground speed and time.

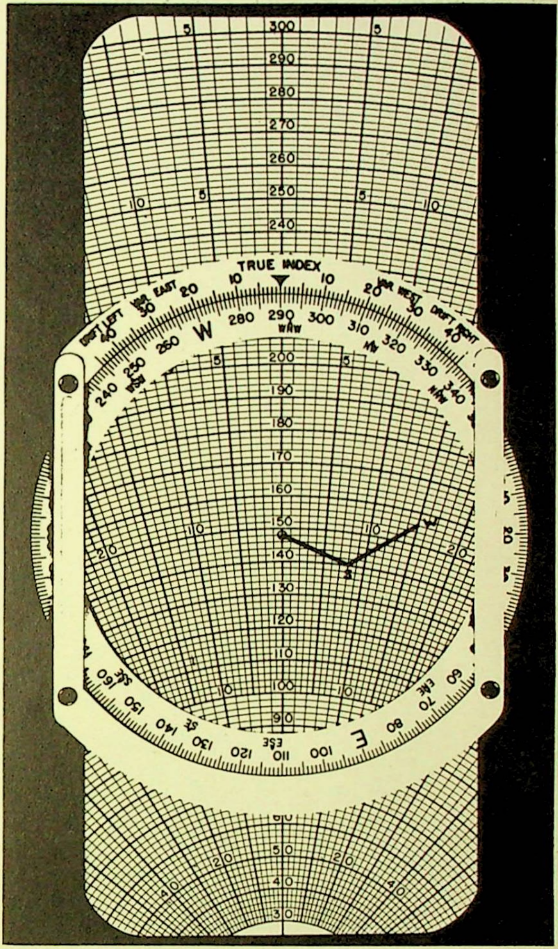


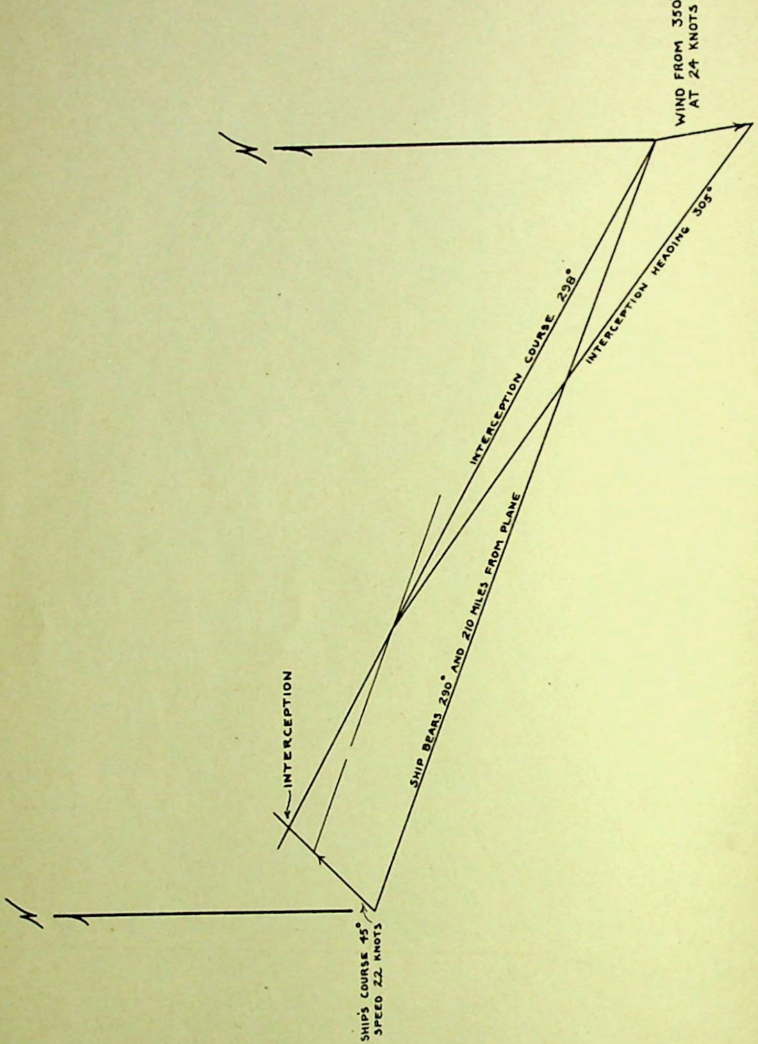
Fig. 28-C

ALTERNATE AIRPORT.
(Radius of action to an Alternate Base.)

The need for the solution of this problem arises from the following situation: A pilot plans a flight between two airports but due to uncertain weather conditions finds that the destination may be below instrument conditions upon arrival. He then selects an alternate airport, within the range of the aircraft, to which he may turn if the weather does close in at the destination. As the plane does not carry enough gas to fly to the destination and then to the alternate, it is evident that at some point on the true course to destination, the plane must turn and fly to the alternate. Since the pilot wishes to stay on the original true course as long as possible in the event the weather clears, he must determine how far out on the original course he may fly before the turn to the alternate must be made. This distance from the departure airport to the turning point is known as the Radius of Action. As in any type of problem, the headings, ground speeds, and E.T.A.'s must also be determined.

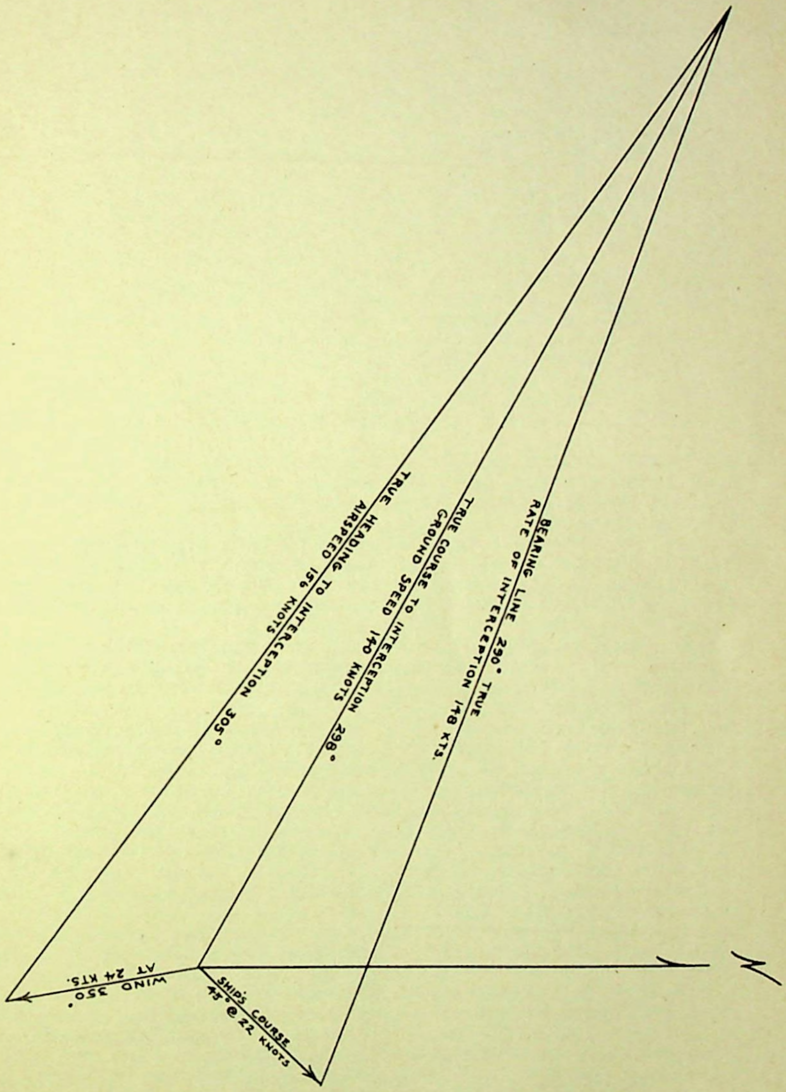
While the graphic solution of the problem will not be discussed here, it is important to understand certain of the symbols that will be mentioned in the procedure. The following symbols will be used in the explanation:

S1 equals the rate of departure.
S2 equals the rate of closure. (Rate of interception.)
"A" is the departure point.



Graphic Solution, Interception Problem

ALTERNATE AIRPORT



Graphic Solution, Interception Problem Relative Movement

"B" is the destination.
"C" is the alternate airport.
"X" is the point of turn.

Problem Type: Alternate Airport.

Given: True course and distance "A" to "B".
True course and distance "A" to "C".
Wind direction and velocity.
True airspeed.
Fuel hours available. (Net fuel hours.)

Required: True heading "A" to "X".
True heading "X" to "C".
True course "X" to "C".
Ground speed "A" to "X".
Ground speed "X" to "C".
Rate of Departure (S1)
Rate of Closure (S2)
Radius of Action (R/A)
Distance "X" to "C".
Time from "A" to "X".
Time from "X" to "C".
The bearing of the line of relative motion.

(a) Set the direction from which the wind is blowing opposite the true index and draw the wind down to the grommet. The arrowhead of the wind line will be at the grommet. Label the end of the wind line "W".

(b) Assume "C", the alternate airport, to be a moving base, or ship, leaving "A" the same time as the plane and arriving at its true position in the fuel hours allotted. Determine the one hour movement of this assumed moving base by dividing the distance from "A" to "C" by the net fuel hours.

(c) Set the true course "A" to "C" against the true index. Plot in the one hour movement of the alternate (as determined in step "b") along the center line from below up to the grommet. Label the end of this line "S".

(d) Set the true course "A" to "B" at the true index and the tail of the wind arrow "W", on true airspeed. Read ground speed "A" to "B" under the grommet. From the radiating line through "W" determine drift and apply to true course to obtain true heading "A" to "B". The radiating line through point "S" represents the bearing of the plane from the ship relative to the true course "A" to "B". Determine angular distance from the center line and apply to true course to obtain bearing. Add or subtract 180 degrees to obtain bearing of ship from plane. Under "S" read rate of departure. (S1)

(e) Set the bearing of ship from plane at the true index. (It will be helpful to pencil-mark an arrow on the compass ring to mark this bearing.) Set the tail of the wind line, "W", on true airspeed. It is now necessary to set up the center line of the grid to represent the true course from the turning point to the ship (true course "X" to "C"), relative to the bearing of ship from plane. Since the radiating line through point "S" will represent the bearing, it is possible to set up the course by making the angular difference between "S" and the center line of the grid, equal to the difference between the pencil-marked bearing and the true index.

(f) With the bearing of ship from plane still set at the true index, note the angular distance of point "S" from the center line. Rotate the compass rose so that the pencil-marked bearing is the same number of degrees from the true index. (If "S" is to the right of the center line rotate the compass rose right, and if "S" is to the left, rotate the compass rose left.) Reset "W" on true airspeed. Again note the angular distance of point "S" from the center line, and then rotate the compass rose so the pencil-marked bearing is the same number of degrees from the true index. Reset "W" on true airspeed. By this method of trial and error, arrive at a final setting that will place the pencil-marked bearing the same number of degrees to the right or left of the true index, that point "S" is to the right or left of the center line. Point "W" must also be on true airspeed.

(g) When the setting described above is accomplished, the true course "X" to "C" will be read against the true index. Under the grommet read ground speed "X" to "C". From the radiating line through point "W", determine drift and apply to true course "X" to "C" to obtain true heading "X" to "C". Under point "S" read rate of closure. (S2)

(h) Using the circular slide rule solve the radius of action formula, to determine the time to turn and the radius of action. (Reference, Page 22, Radius of Action Formula.)

(i) Subtract time to the turning point from the net fuel hours to obtain the time "X" to "C". Knowing ground speed "X" to "C" and time "X" to "C", use the slide rule scale to determine the distance "X" to "C".

Example:

Given: True course "A" to "B" 83 degrees, distance 532 miles.
True course "A" to "C" 118 degrees, distance 220 miles.
Wind from 170 degrees at 18 miles per hour.
True airspeed 156 miles per hour.
Net fuel hours 5½.

Required: True heading "A" to "X". True heading "X" to "C".
True course "X" to "C". Ground speed "X" to "C".
Time "X" to "C". Distance "X" to "C".
Time "A" to "X". Radius of Action.
Rate of Departure. Rate of Closure.

(a) Set the direction from which the wind is blowing, 170 degrees, opposite the true index and draw the wind force, 18 miles per hour, down to the grommet. Label the tail of the wind line "W". (See Fig. 29-A, Page 68 .)

(b) Assume "C", the alternate airport, to be a ship leaving "A" the same time as the plane and arriving at its true position in the net fuel hours allotted. Determine the one hour movement of this assumed moving base, 40 miles, by dividing the distance "A" to "C", 220 miles, by 5½ net fuel hours.

(c) Set the true course "A" to "C", 118 degrees, against the true index. Plot in the one hour movement of the alternate, 40 miles, along the center line, from below up to the grommet. Label the end of this line "S". (See Fig. 29-B, Page 68 .)

(d) Set the true course "A" to "B", 83 degrees, at the true index and the tail of the wind arrow, "W", on true air speed, 156 m.p.h. Read the ground speed "A" to "B", 154 m.p.h., under the grommet. Under "S" read the rate of departure, 123 m.p.h. From the radiating line through "W" determine the drift, 6½ degrees right, and apply to the true course, 83 degrees, to obtain the true heading "A" to "B", 89½ degrees. The radiating line through point "S" represents the bearing of the plane from the ship relative to the true course "A" to "B". Determine the angular distance from the center line, 10½ degrees left, and apply to the true course, 83 degrees, to obtain the bearing, 72½ degrees. Add 180 degrees to this bearing to get the bearing of the ship from the plane, 252½ degrees. (See Fig. 29-C, Page 69 .)

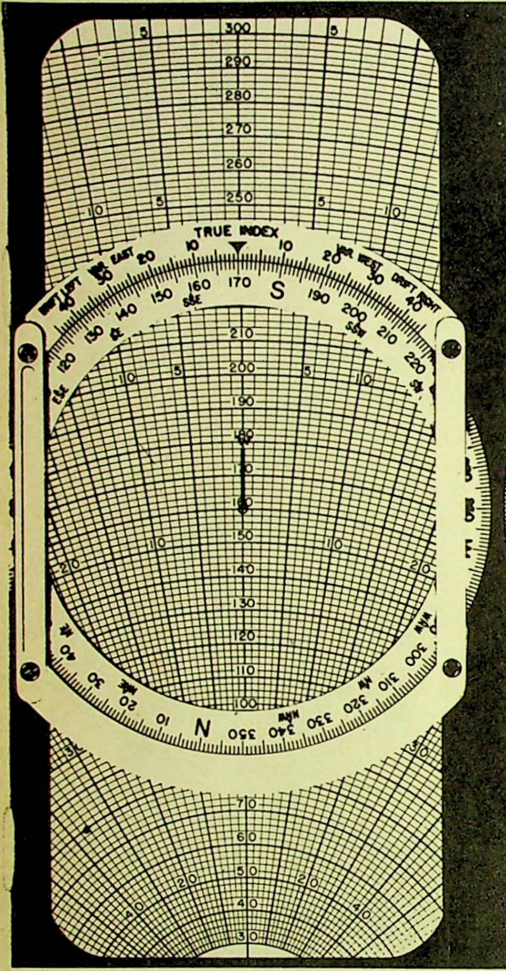


Fig. 29-A

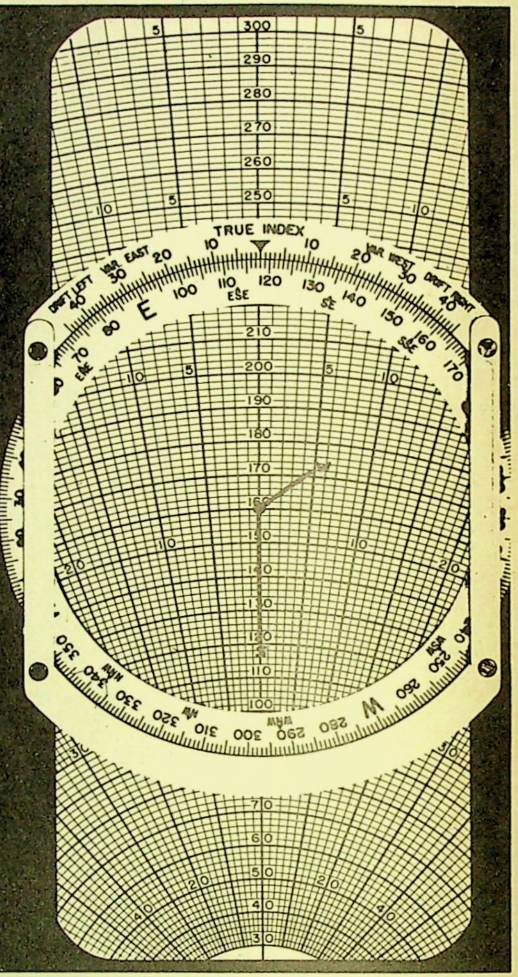


Fig. 29-B

(e) Set the bearing of ship from plane, 252½ degrees, against the true index. (Pencil-mark an arrow on the compass ring to mark this bearing.) Set the tail of the wind line, "W", on 156 true airspeed. It is now necessary to set up the center line of the grid to represent the true course from the turning point to the ship (true course "X" to "C"), relative to the bearing of ship from plane of 252½ degrees. Since the radiating line through point "S" will represent the bearing, it is possible to set up the course by making the angular difference between "S" and the center line of the grid, equal to the difference between the pencil-marked bearing and the true index. (See Fig. 29-D, Page 69.)

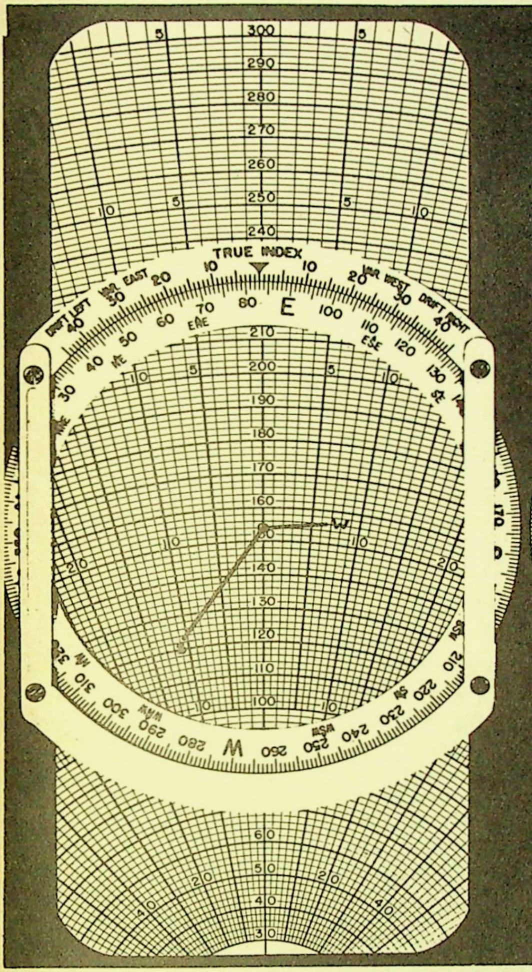


Fig. 29-C

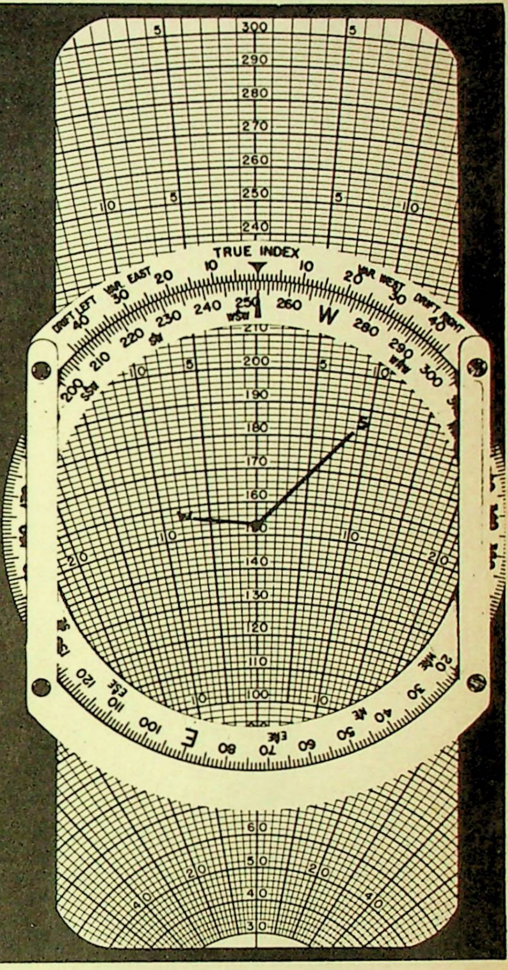
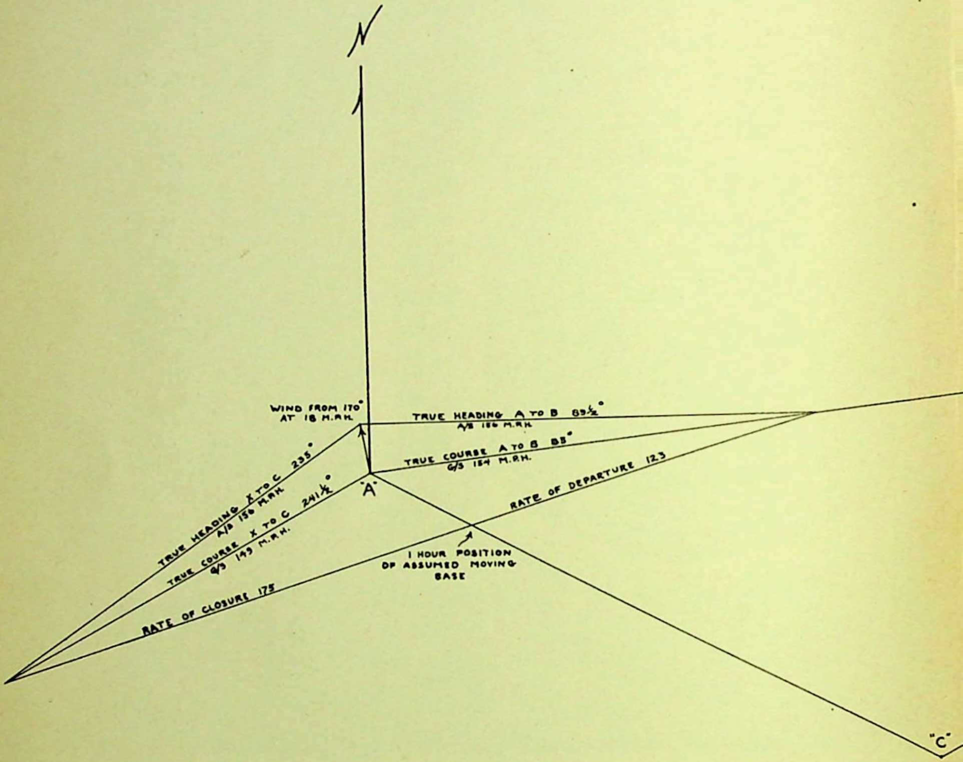


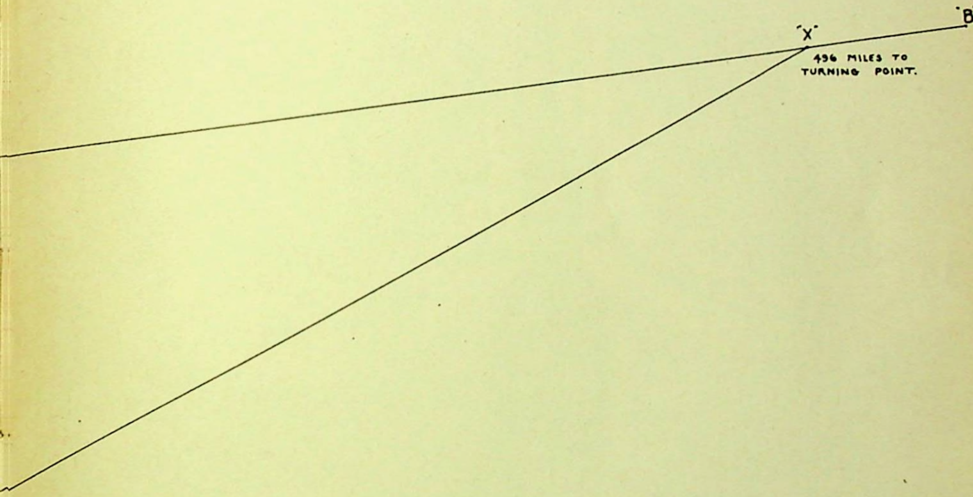
Fig. 29-D

(f) With the pencil-marked bearing still set at the true index, note that point "S" is nearly 9 degrees right of the center line. Rotate the compass ring so that the pencil-marked bearing is 9 degrees right of the true index. Reset "W" on 156 true airspeed. Point "S" is now 10½ degrees right. (See Fig. 29-E, Page 72.) Rotate the compass ring until the pencil-marked bearing is 11 degrees right of the true index. Again set "W" on true airspeed. Point "S" is now 11 degrees right of the center line also, and the center line of the grid now represents the true course from the turning point to the ship. Read the course, 241½ degrees, opposite the true index. (See Fig. 29-F, Page 72.)


N
WIND FROM 170° AT 18 M.P.H.
TRUE HEADING A TO B 83½° A/S 156 M.P.H.
TRUE COURSE A TO B 85° G/S 154 M.P.H.
"A"
TRUE HEADING X TO C 235° A/S 156 M.P.H.
TRUE COURSE X TO C 241½° G/S 149 M.P.H.
RATE OF DEPARTURE 123
1 HOUR POSITION OF ASSUMED MOVING BASE
RATE OF CLOSURE 175
"C"

Graphic Solution, A

ALTERNATE AIRPORT



ate Airport Problem

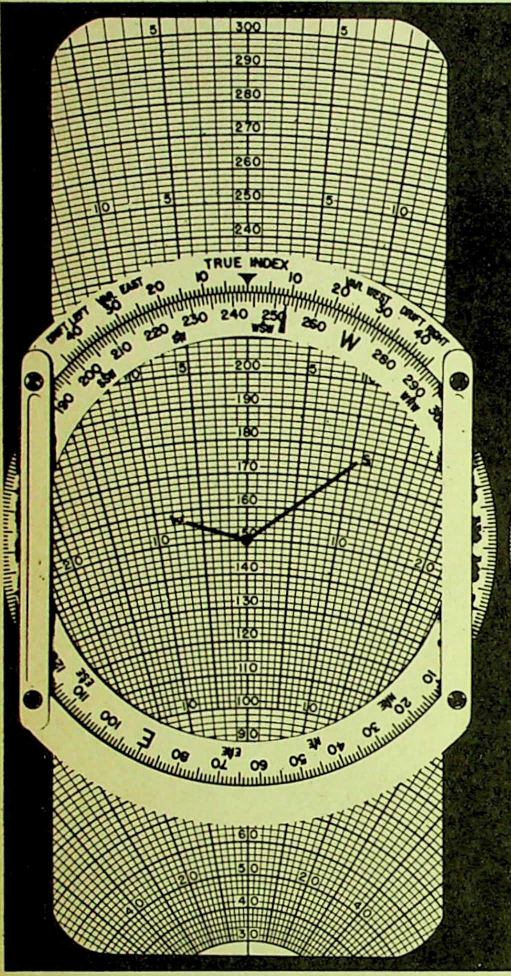


Fig. 29-E

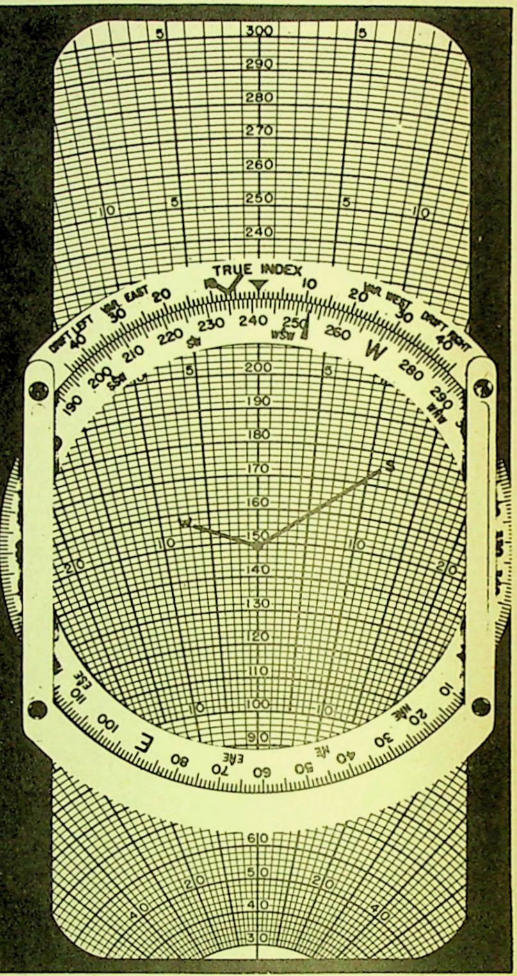


Fig. 29-F

(g) Under the grommet read ground speed "X" to "C", 149 miles per hour. Under "S" read rate of closure, 175 m.p.h. From the radiating line through point "W" determine drift, 6½ degrees left, and apply to the true course of 241½ to obtain true heading, 235 degrees, "X" to "C".

(h) Using the circular slide rule solve the radius of action formula to determine the time to turn, 3 hours and 14 minutes, and the radius of action, 496 miles.

(i) Subtract the time to the turning point, 3 hours and 14 minutes, from the net fuel hours, 5½, to obtain the time "X" to "C", 2 hours and 16 minutes. Knowing the ground speed "X" to "C", 149 m.p.h., and the time as found above, use the slide rule scale to determine the distance "X" to "C", 337 miles.

Examples for practice:

88. Given: True course "A" to "B" 314 degrees.
Distance "A" to "B" 620 miles.
True course "A" to "C" 272 degrees.
Distance "A" to "C" 294 miles.
True airspeed 165 miles per hour.
Net fuel hours 6.
Wind from 203 degrees at 20 miles per hour.
Required: True heading "A" to "B". 309 - 314
Ground speed "A" to "B". 167 180
True course "X" to "C". 173
True heading "X" to "C". 178
Ground speed "X" to "C". 143
Rate of Departure.
Rate of Closure.
Time from "A" to "X".
Time from "X" to "C".
Radius of Action.
Bearing of the line of Relative Motion.

89. Given: True course "A" to "B" 66 degrees.
Distance "A" to "B" 350 miles.
True course "A" to "C" 94 degrees.
Distance "A" to "C" 235 miles.
Wind from 207 degrees at 27 miles per hour.
True airspeed 100 miles per hour.
Net fuel hours 5.
Required: True heading "A" to "B".
Ground speed "A" to "B".
True course "X" to "C".
True heading "X" to "C".
Ground speed "X" to "C".
Time "X" to "C".
Time "A" to "X".
Rate of Departure.
Rate of Closure.
Radius of Action.
Bearing of the line of relative motion.

90. Given: A pilot is ordered to scout out from a carrier on a true course of 160 degrees. The carrier is on a true course of 148 degrees at 28 knots. The true airspeed of the plane is 144 knots and there is fuel aboard for four hours flight. The wind is from 60 degrees at 30 knots.
Required: True heading and groundspeed on leg out.
Distance on leg out.
Time on leg out.
True course and ground speed on second leg. (From the turning point back to the ship.)
Time on second leg.
Distance on second leg.
Rate of Departure.
Rate of Closure.
The bearing of the line of relative motion.

Note: The problem given above is known as Radius of Action from a Moving Base or GEOGRAPHIC SEARCH. Since it is actually the basis of the Alternate Airport problem, it follows that the solution is exactly the same. The true course the pilot is ordered to scout corresponds to the true course "A" to "B" in the Alternate Airport problem. Referring to the Alternate Airport problem, step (b), note that the Alternate Airport is assumed to be a moving base. In the preceding example the pilot actually is working from a moving base and its one hour movement will, of course, be the ship's speed of 28 knots. The distance the pilot can fly on the first leg, or leg out, will correspond to the "A" to "X" leg of the Alternate Airport problem, and the second leg, back to the ship, will correspond to the "X" to "C" leg of the Alternate Airport.

* *

In the preceding Alternate Airport Problems the given information has always included the true course and distance from "A" to "B" and from "A" to "C". In some cases the given information may not be in this order. For example, the Civil Aeronautics Authority set up the Alternate Airport problem as follows: Given true course and distance from "A" to "B" and true course and distance from "B" to "C". Since true course and distance "A" to "C" must be determined in order to solve the problem on the computer, the following explanation is given:

Problem Type: To find true course and distance "A" to "C", knowing true course and distance "A" to "B" and "B" to "C".

(a) Set the true course "B" to "C" opposite the true index, and lay off the distance "B" to "C" along the center line upward from the grommet. Label this point "C".
(b) Set the true course "A" to "B" against the true index, and the grommet on the distance from "A" to "B".
(c) From the concentric circle passing through "C" determine the distance from "A" to "C". From the radiating line passing through "C" determine the angular distance of point "C" from the center line, and apply to true course "A" to "B" to obtain true course "A" to "C".

Example: Given true course "A" to "B" 40 degrees.
Distance "A" to "B" 200 miles.
True course "B" to "C" 85 degrees.
Distance "B" to "C" 54 miles.
What is the true course and distance "A" to "C"?

(a) Set the true course "B" to "C", 85 degrees, opposite the true index and lay off the distance "B" to "C", 54 miles, upward from the grommet. The end of the line represents "C", the alternate airport. (See Fig. 30-A, Page 75.)
(b) Set the true course "A" to "B", 40 degrees, opposite the true index. Set the grommet on the distance "A" to "B" of 200 miles. (See Fig. 30-B, Page 75.)
(c) From the concentric circle through point "C" read the distance "A" to "C", 241 miles. From the radiating line through point "C" determine angular distance from center line, 9 degrees right and apply to true course "A" to "B", 40 degrees, to obtain true course "A" to "C", 49 degrees. (See Fig. 30-B, Page 75.)

Note: Problems involving distances too great to plot on the computer can still be accurately solved by reducing the scale to one-half or one-quarter. Distances only are reduced. All angular values remain unchanged.

Examples for practice:

91. Given true course "A" to "B" 276 degrees, distance 480 miles. True course "B" to "C" 358 degrees, distance 110 miles. Find true course and distance "A" to "C".
92. Given true course "A" to "B" 8 degrees, distance 760 miles. True course "B" to "C" 313 degrees, distance 192 miles. What is the

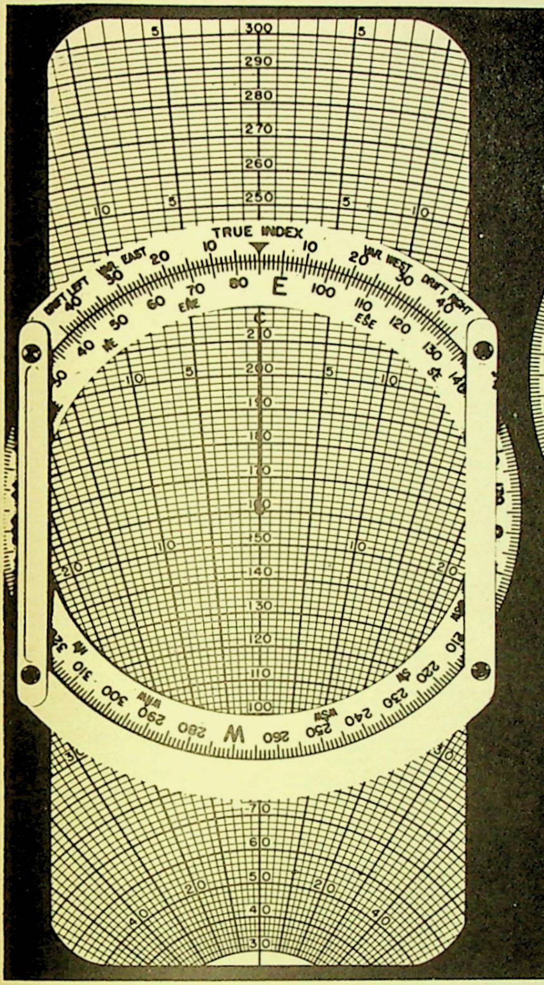


Fig. 30-A

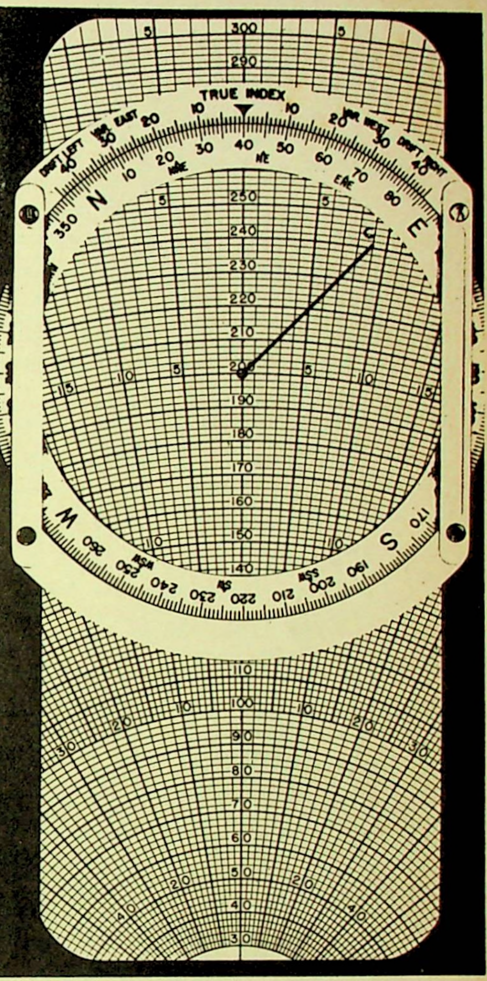


Fig. 30-B

true course and distance "A" to "C"?

93. Given true course "A" to "B" 162 degrees, distance 560 miles. True course "B" to "C" 240 degrees, distance 200 miles. Find true course and distance "A" to "C".

ALTERNATE SOLUTION FOR RADIUS OF ACTION TO A MOVING BASE.

As previously explained, the Alternate Airport problem is actually a radius of action to a moving base. Since the Alternate base is assumed to be a ficticious ship, the one hour movement (speed) of the ship will in many cases be too great to plot on the disk of the computer. The method that follows, while somewhat less accurate and more difficult to work, will often solve problems that cannot be worked by the first method.

Given: True course and distance "A" to "B".
True course and distance "A" to "C".
True airspeed.
Wind direction and velocity.
Net fuel hours.

Required: True heading "A" to "X".
Ground speed "A" to "X".
Distance "A" to "X".
Time "A" to "X".
True heading "X" to "C".
Time "X" to "C".

(a) Set direction from which the wind is blowing opposite the true index. Draw in the wind, at the given velocity, from above down to the grommet. Label the end of the wind line "W".

(b) Set the true course "A" to "B" opposite the true index, and the tail of the wind line, "W", on true airspeed. Under the grommet read ground speed "A" to "X". From the radiating line through "W" determine drift and apply to true course "A" to "B" to obtain true heading "A" to "B".

(c) Assume the grommet to represent the Alternate Airport "C". Distances will usually be too great to plot full scale on the computer. When a reduction in scale is necessary use the net fuel hours as the reducing factor.

(d) Divide distance "A" to "C" by net fuel hours and set the grommet on this value on the center line scale. Set the true course "A" to "C" opposite the true index. Determine the radiating line, to the right or left of the center line, that represents the true heading "A" to "B", as found in step (b). Carefully trace a pencil line over this heading line, from the true airspeed circle downward. (This actually represents air distance that would be flown in the fuel hours allotted.) Mark the end of the heading line "H".

(e) Reverse the grid and with the aid of the rectangular scale align points "H" and "W" along one of the vertical lines. Determine the midpoint between "H" and "W" and from this midpoint project a horizontal line to intersect the heading line. Mark this intersection point "T". The direction of point "W" from point "T" represents the heading from the turning point to "C". Align points "W" and "T" along a vertical line with point "W" at the top. Opposite the true index read true heading "X" to "C".

(f) Reverse the grid and set the true course "A" to "C" against the true index. Set the grommet on distance "A" to "C" as in step (d). From the speed circle passing through point "T" read air distance out from "A". Since this is reduced scale, multiply this value by fuel hours to obtain actual distance. Divide this true air distance by air speed to find time to the turning point. Knowing time to the turning point, and ground speed from step (b), use the circular slide rule to find distance to the turning point.

(g) Subtract time "A" to "X" from net fuel hours to find time from "X" to "C". Knowing true heading "X" to "C", wind direction and velocity, and true airspeed, solve vector triangle to determine true course and ground speed "X" to "C". (Problem Type I, page 29 .) With ground speed "X" to "C" and time "X" to "C", the distance from "X" to "C" can be found.

Example:

Given: True course "A" to "B" 290 degrees.

ALTERNATE SOLUTION FOR RADIUS OF ACTION TO A MOVING BASE

Distance "A" to "B" 380 miles.
True course "A" to "C" 306 degrees.
Distance "A" to "C" 384 miles.
True airspeed 130 miles per hour.
Wind from 75 degrees at 30 miles per hour.
Net fuel hours, 3.
Required: True heading "A" to "X".
Ground speed "A" to "X".
Distance "A" to "X".
Time "A" to "X".
True heading "X" to "C".
Time "X" to "C".

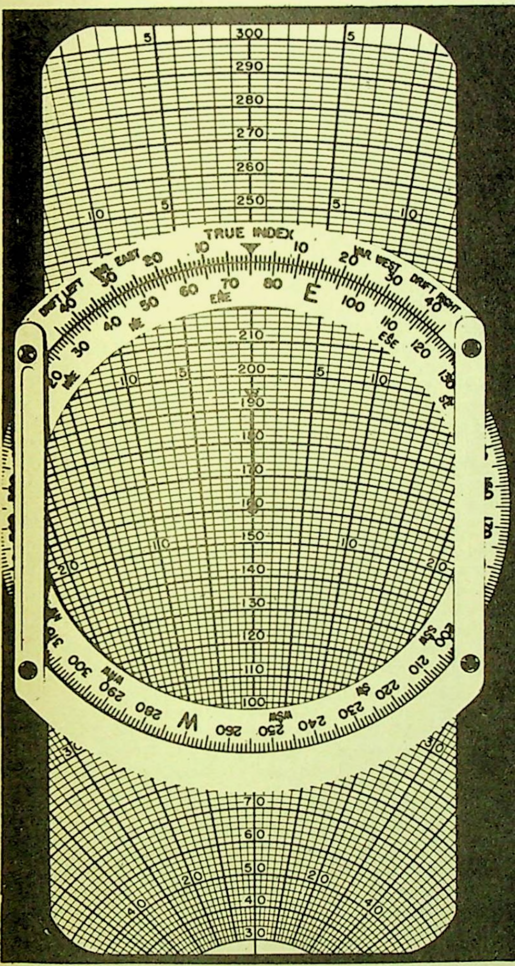


Fig. 31-A

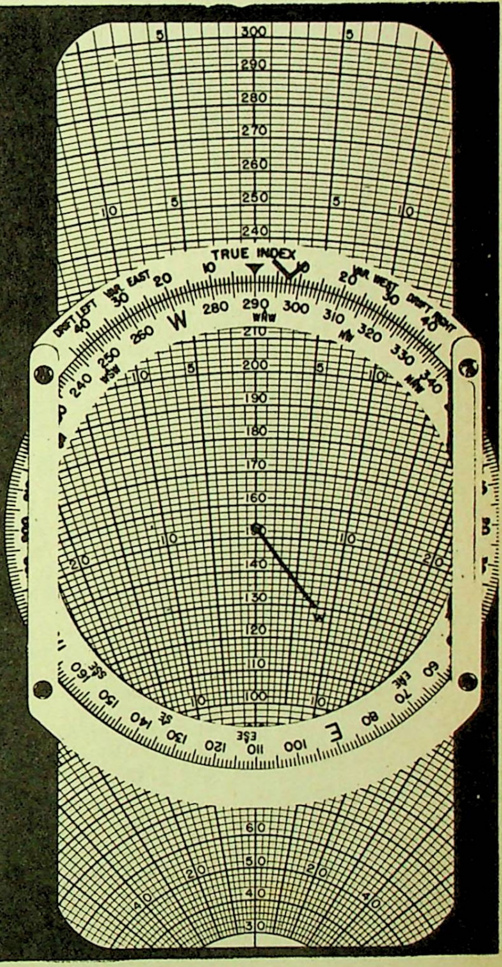


Fig. 31-B

Ground speed "X" to "C".
Distance "X" to "C".

(a) Set wind direction, 75 degrees, opposite the true index and plot the wind at 30 m.p.h., from above down to the grommet. Label the end of the wind line "W". (See Fig. 31-A, Page 77.)

(b) Set true course "A" to "B", 290 degrees, at the true index, and the the tail of the wind line, "W", on true air speed of 130 m.p.h. Under the grommet read ground speed "A" to "B", 153 m.p.h. From the radiating line through "W" determine drift (7½ degrees right) and apply to true course to obtain true heading "A" to "B" of 297½ degrees. (See Fig. 31-B, Page 77.)

(c) The grommet will now be set up to represent the Alternate Air-

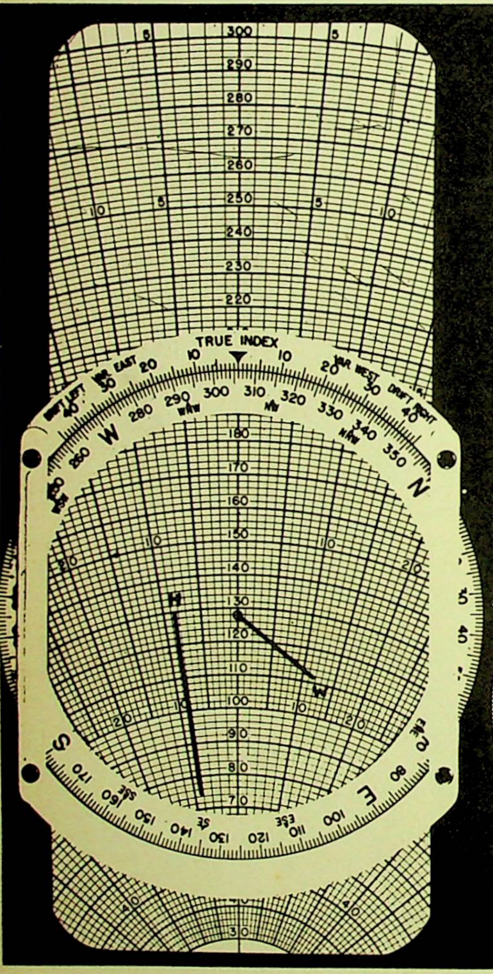


Fig. 31-C

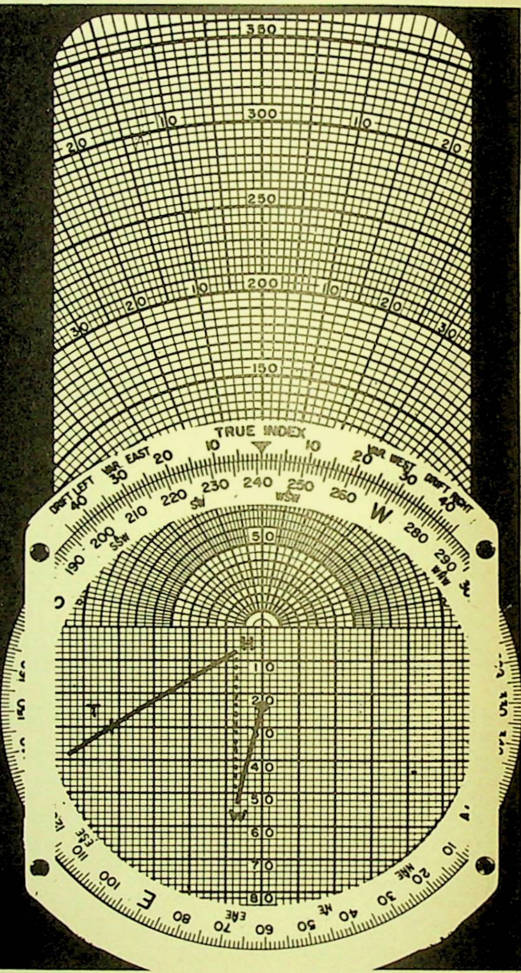


Fig. 31-D

port "C". Since a reduction in scale is necessary, the net fuel hours will be used as the reducing factor. Divide the distance "A" to "C", 384 miles, by 3 (net fuel hours) to obtain distance "A" to "C", 128 miles at one-third scale. Set the grommet on 128 on the center line scale. Set the true course "A" to "C", 306 degrees, at the true index. The radiating line 8½ degrees to the left of the center line now represents the true heading of 297½ degrees, relative to the true course of 306 degrees. Carefully trace a pencil line over this heading line, from the 130 m.p.h. airspeed circle downward. (This represents air distance that would be flown in the fuel hours allotted.) Mark the end of the heading line "H". (See Fig. 31-C, Page 78 .)

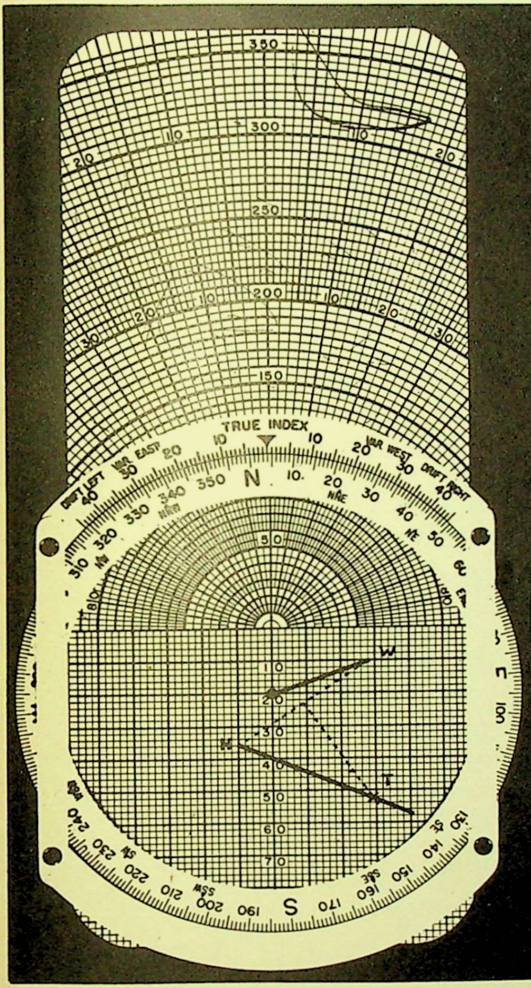


Fig. 31-E

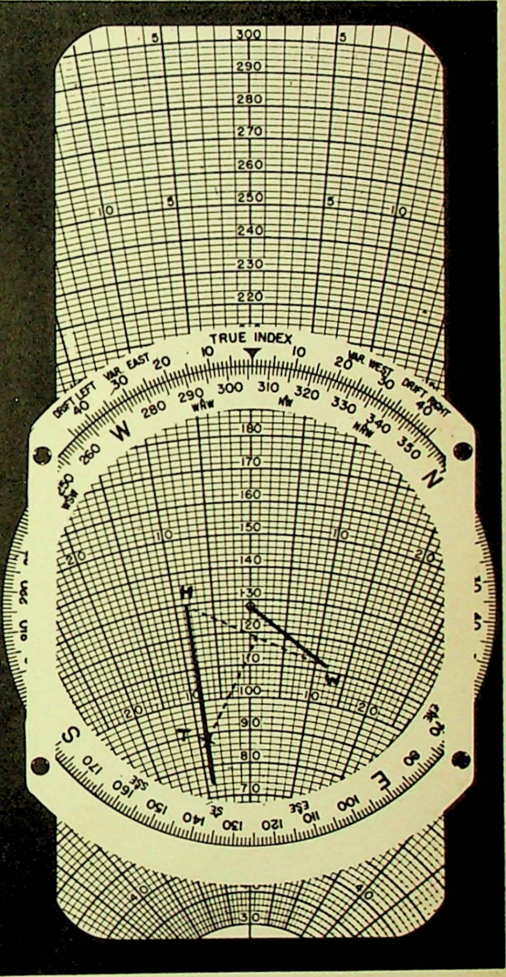
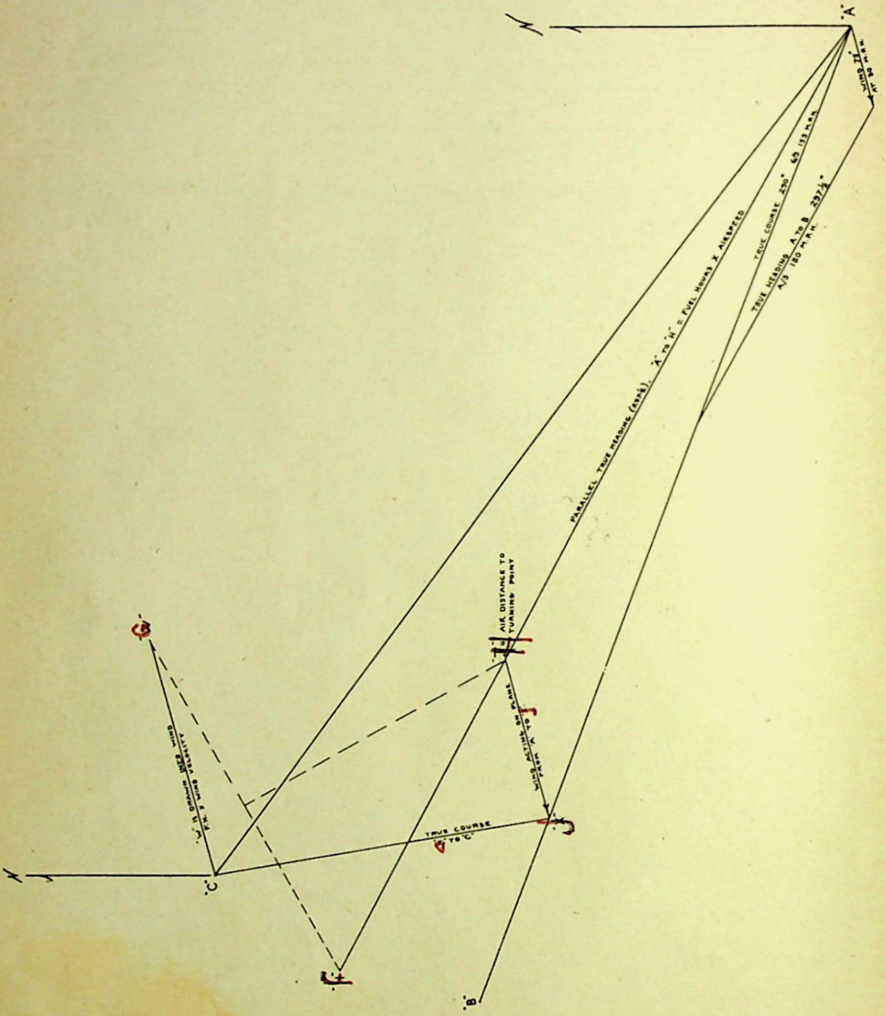
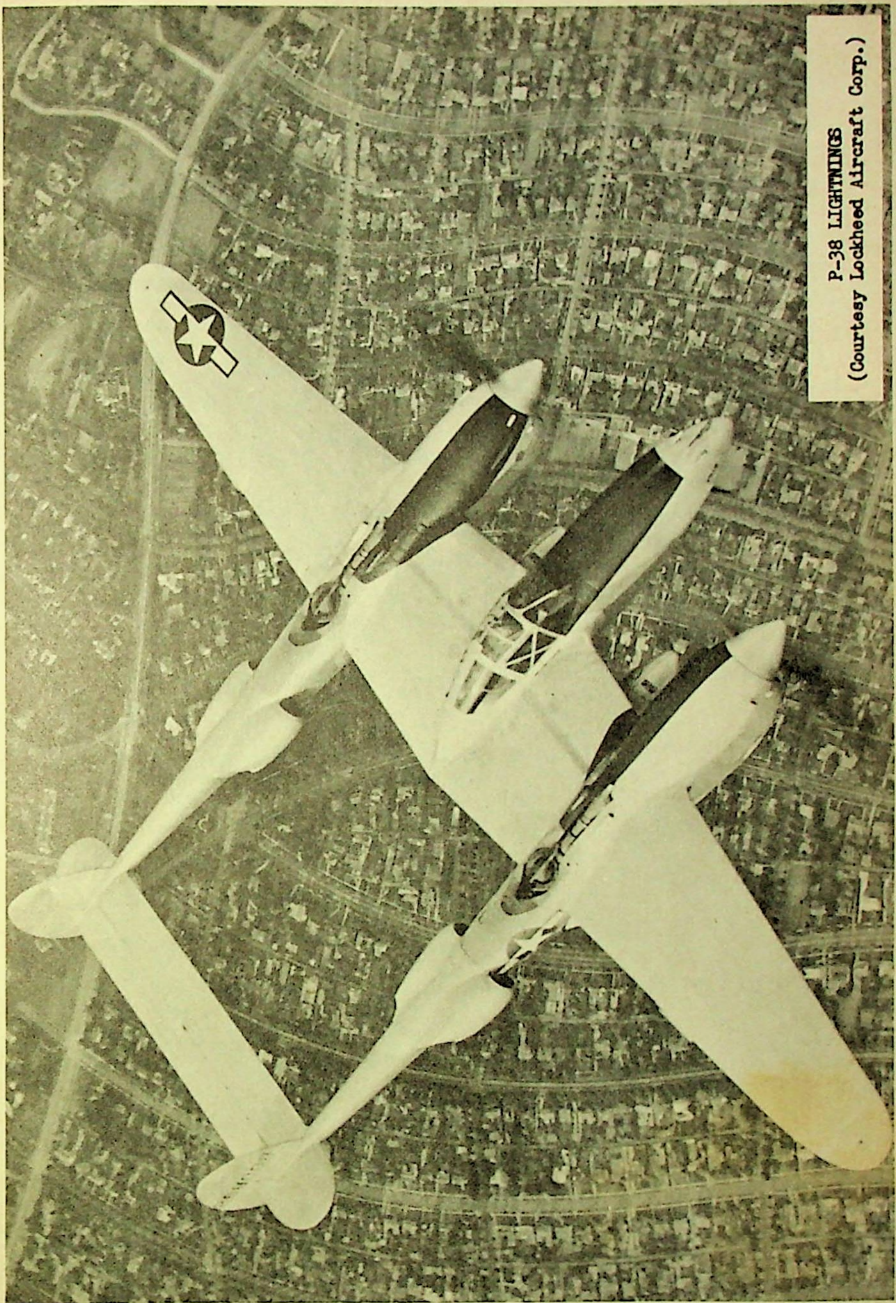


Fig. 31-F


"A"
WIND 22° AT 30 M.P.H.
TRUE COURSE 250° GS 173 M.P.H.
TRUE HEADING A TO B 237½° A/S 180 M.P.H.
PARALLEL TRUE HEADING (237½). "A" TO "H" = FUEL HOURS X AIRSPEED
AIR DISTANCE TO TURNING POINT
H
WIND ACTING ON PLANE FROM "A" TO J
J
TRUE COURSE "J" TO "C"
"W" IS DRAWN INTO WIND F.H. X WIND VELOCITY
G
"C"
L
"B"

Graphic Solution, Alternate Airport Problem Alternate Solution



P-38 LIGHTNINGS
(Courtesy Lockheed Aircraft Corp.)

(d) Reverse the grid and with the aid of the rectangular scale align points "H" and "W" along one of the vertical lines. Determine the midpoint between "H" and "W" and from this midpoint project a horizontal line to intersect the heading line. Mark this intersection point "T". (See Fig. 31-D, Page 78.) The direction of point "W" from point "T" represents the heading from the turning point to "C". Align points "W" and "T" along a vertical line with point "W" at the top. Opposite the true index read true heading "X" to "C" of 4 degrees. (See Fig. 31-E Page 79.)

(e) Reverse the grid and set the true course "A" to "C", 306 degrees, at the true index. Set the grommet on distance "A" to "C", 128 miles. From the speed circle passing through point "T" read air distance out from "A" of 88 miles. Since this is reduced scale, multiply this value by 3 to obtain actual distance of 264 miles. Dividing this true air distance by airspeed, 130 m.p.h., will give the time to the turning point of 2 hours and 2 minutes. Knowing time to the turning point and the ground speed out of 153 m.p.h., step (b), the distance to the turning point is found to be 311 miles. (See Fig. 31-F, Page 79.)

(f) Subtract the time from "A" to "X", 2:02, from the 3 net fuel hours to obtain time from "X" to "C" of 58 minutes. Knowing true heading "X" to "C", 4 degrees, from step (d), wind direction and velocity, and true airspeed, solve a vector triangle to determine true course "X" to "C", 351 degrees, and ground speed "X" to "C", 124 m.p.h. With this ground speed and time "X" to "C" of 58 minutes, distance "X" to "C" is found to be 120 miles.

Examples for practice:

94. Given: True course "A" to "B" 66 degrees.
Distance "A" to "B" 294 miles.
True course "A" to "C" 63 degrees.
Distance "A" to "C" 192 miles.
True airspeed 120 miles per hour.
Wind from 207 degrees at 27 miles per hour.
Net fuel hours, 3.
Required: True heading "A" to "X".
Ground speed "A" to "X".
Distance "A" to "X".
Time "A" to "X".
True heading "X" to "C".
Time "X" to "C".
Ground speed "X" to "C".
Distance "X" to "C".

95. Given: True course "A" to "B" 242 degrees.
Distance "A" to "B" 448 miles.
True course "A" to "C" 230 degrees.
Distance "A" to "C" 318 miles.
True airspeed 140 miles per hour.
Wind from 350 degrees at 26 miles per hour.
Net fuel hours, 3.
Required: True heading "A" to "X".
Ground speed "A" to "X".
Distance "A" to "X".
Time "A" to "X".
True heading "X" to "C".
True course "X" to "C".
Time "X" to "C".
Ground speed "X" to "C".
Distance "X" to "C".

96. Given: True course "A" to "B" 70 degrees.
Distance "A" to "B" 620 miles.
True course "A" to "C" 85 degrees.
Distance "A" to "C" 520 miles.
True airspeed 130 miles per hour.
Wind from 330 degrees at 22 miles per hour.
Net fuel hours, 5.
Required: True heading "A" to "X".
Ground speed "A" to "X".
Distance "A" to "X".
Time "A" to "X".
True heading "X" to "C".
True course "X" to "C".
Time "X" to "C".
Distance "X" to "C".
Ground speed "X" to "C".

RELATIVE SEARCH. (Out and In Flight from a Moving Carrier.)

This type problem is similar to Radius of Action from a moving base, the only difference being that the pilot is given a bearing that he must maintain from the ship throughout the flight. The pilot must then determine what true course and heading to fly in order to maintain this bearing, the distance to the turning point (R/A), and the true course and heading from the turning point back to the ship.

Given: Bearing plane is to maintain from the ship.
Ship's course and speed.
Wind direction and velocity.
True airspeed of the plane.
Net fuel hours.
Required: True course out.
True heading out.
Ground speed out.
Rate of departure (S1).
Rate of closure (S2).
True heading back.
True course back.
Ground speed back.
Time to the turning point.
Time from the turning point to the ship.

(a) Set the ship's course against the true index and plot in the ship's speed upward from the grommet. Label the end of this line "S".
(b) Set direction from which the wind is blowing at the true index. Reverse the grid and with the aid of the rectangular grid, plot the wind, at the given velocity, from above down to point "S". Label the end of the wind line "W".
(c) Reverse the grid and set the bearing the plane is to maintain from the ship at the true index. Set point "W" on true airspeed. Read rate of departure (S1) under the grommet. Under point "S" read ground speed out. The radiating line through point "S" represents the true course out relative to the bearing of plane from ship. Determine the angular distance from the center line and apply to bearing to determine true course out. The radiating line through point "W" represents true heading out. Determine angular distance from center line and apply to bearing to find true heading out.
(d) Set bearing of ship from plane at the true index. (Given bearing plus or minus 180 degrees.) Set point "W" on true airspeed. Under the grommet read rate of closure (S2). Under "S" read ground speed back. The radiating line through point "S" repre-

sents true course back, relative to the bearing of ship from plane. Determine angular distance from center line and apply to bearing to find true course back. Determine true heading back, in the same manner, from the radiating line through point "W".

(e) Knowing S1 and S2 and the net fuel hours, solve R/A formula on the slide rule to determine time to the turning point. Subtract time to the turning point from net fuel hours to determine time back. Knowing time to the turning point and ground speed out, use the circular slide rule to find distance to the turning point.

Example:

Given: Ships' course 50 degrees, speed 26 knots.
True airspeed of plane 140 knots.
Wind from 10 degrees at 20 knots.
Net fuel hours 4.
Plane is to maintain a true bearing of 320 degrees from the ship.

Required: True course and ground speed out.
True heading out.
Time and distance out.
True course and ground speed in.
True heading in.
Rate of departure.
Rate of closure.

(a) Set the ship's course, 50 degrees, against the true index and plot in the ship's speed, 26 knots, upward from the grommet. Label the end of this line "S". (See Fig. 32-A, Page 85 .)

(b) Set direction from which the wind is blowing, 10 degrees, at the true index. Reverse the grid and with the aid of the rectangular scale plot in the wind, at 20 knots, from above down to point "S". Label the end of the wind line "W". (See Fig. 32-B, Page 85 .)

(c) Reverse the grid and set the bearing the plane is to maintain from the ship, 320 degrees, at the true index. Set point "W" on true airspeed of 140. Read rate of departure, 121, under the grommet. Under point "S" read ground speed out, 124 knots. The radiating line through point "S" represents the true course out, relative to the bearing of plane from ship. Determine angular distance from the center line (12 degrees right) and apply to the bearing of 320 degrees, to determine true course out, 332 degrees. The radiating line through point "W" represents the true heading out (17 degrees right) and applied to the bearing gives a heading out of 337 degrees. (See Fig. 32-C, Page 86 .)

(d) Set bearing of ship from plane, 140 degrees, at the true index. (320 degrees minus 180 degrees.) Set point "W" on true airspeed, 140 knots. Under the grommet read rate of closure, 147. Under "S" read ground speed in, 149 knots. The radiating line through point "S" represents true course in, relative to the bearing of 140 degrees. Determine angular distance from center line (10 degrees left) and apply to the bearing to find true course in, 130 degrees. Determine true heading in, 123 degrees, from the radiating line through point "W". (See Fig. 32-D, Page 86 .)

(e) Knowing the rate of departure, 121 knots, and the rate of closure, 147 knots, solve the radius of action formula on the circular slide rule to determine the time to turning point, 2 hours and 12 minutes. Subtract this time from the net fuel hours, 4, to determine the time back, 1 hour and 48 minutes. Knowing the time to turning point, 2 hours and 12 minutes, and the ground speed out, 124 knots, solve a time, speed, distance problem on the slide rule to find the distance to turning point, 272 nautical miles.

Examples for practice:

97. Given: Ship's course 358 degrees, speed 32 knots.
Plane's true airspeed 130 knots.
Wind from 110 degrees at 25 knots.
Net fuel hours, 3.
Plane is to maintain a true bearing of 40 degrees. from the ship.
Required: True course and ground speed out.

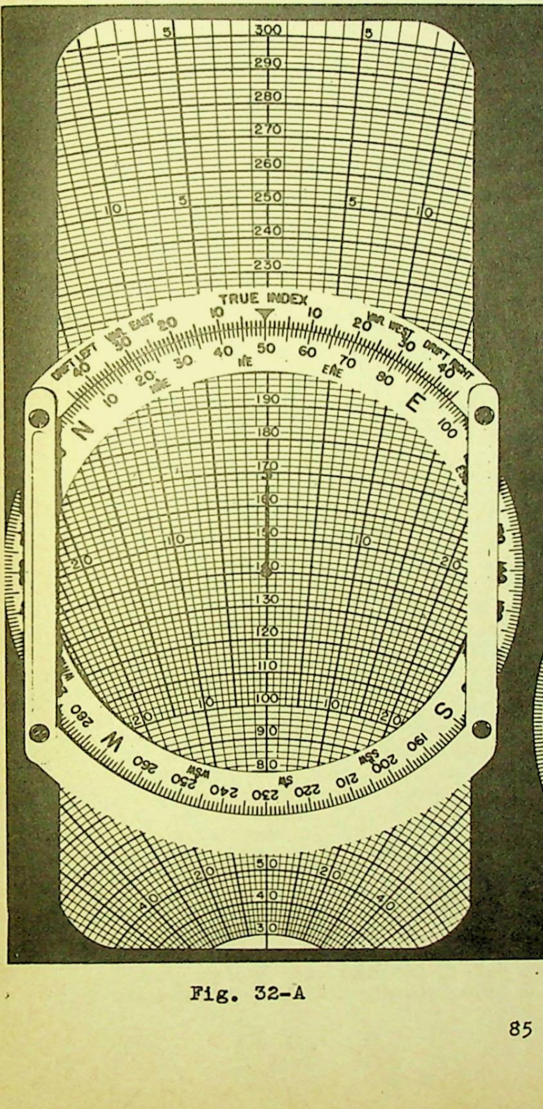


Fig. 32-A

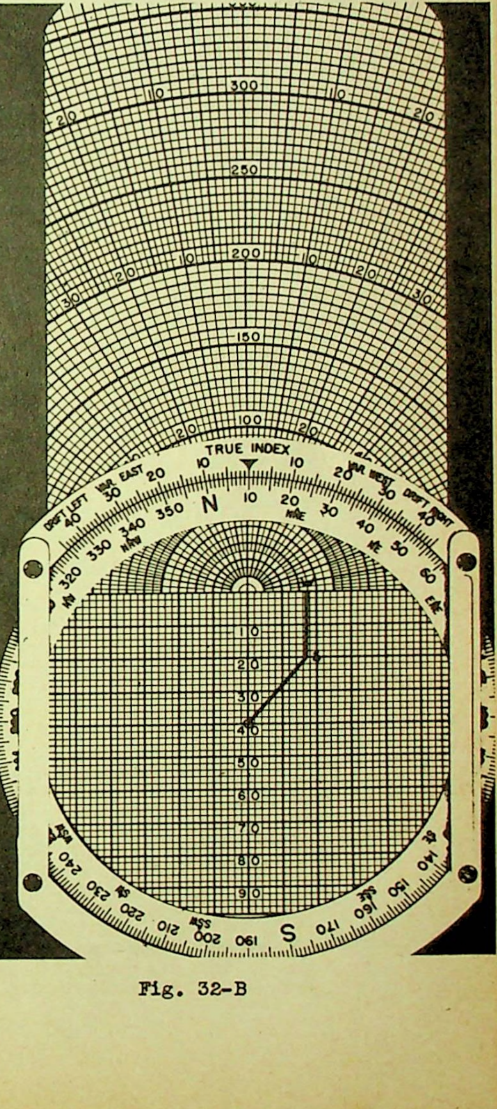


Fig. 32-B

True heading out.
Time and distance out.
True course and ground speed in.
True heading in.
Rate of departure.
Rate of closure.

98. Given: Ship's course 183 degrees, speed 30 knots.
Plane's true airspeed 125 knots.
Wind from 92 degrees at 30 knots.
Net fuel hours, 5.
Plane is to maintain a true bearing of 235 degrees from the ship.

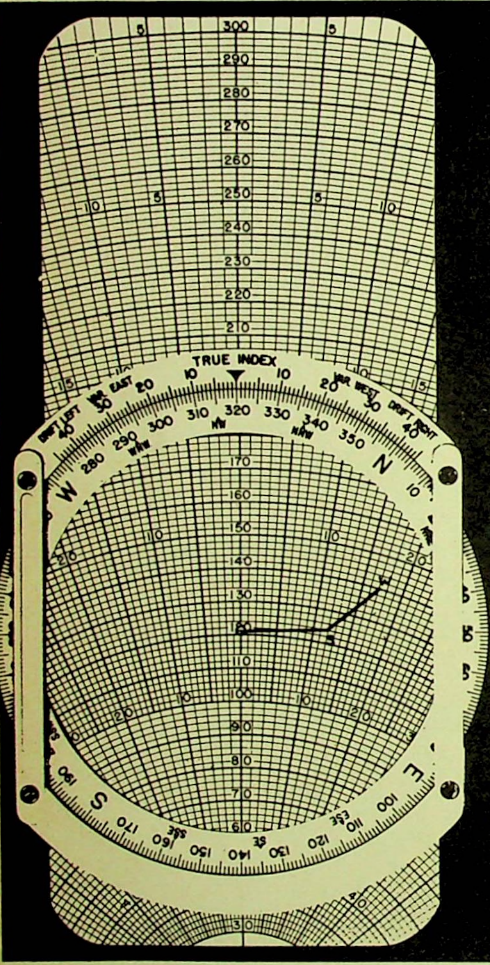


Fig. 32-C

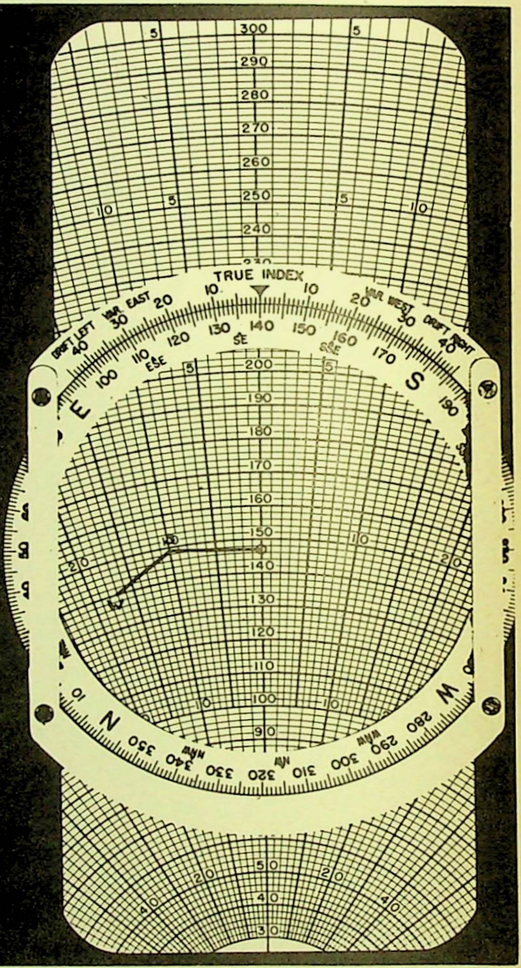
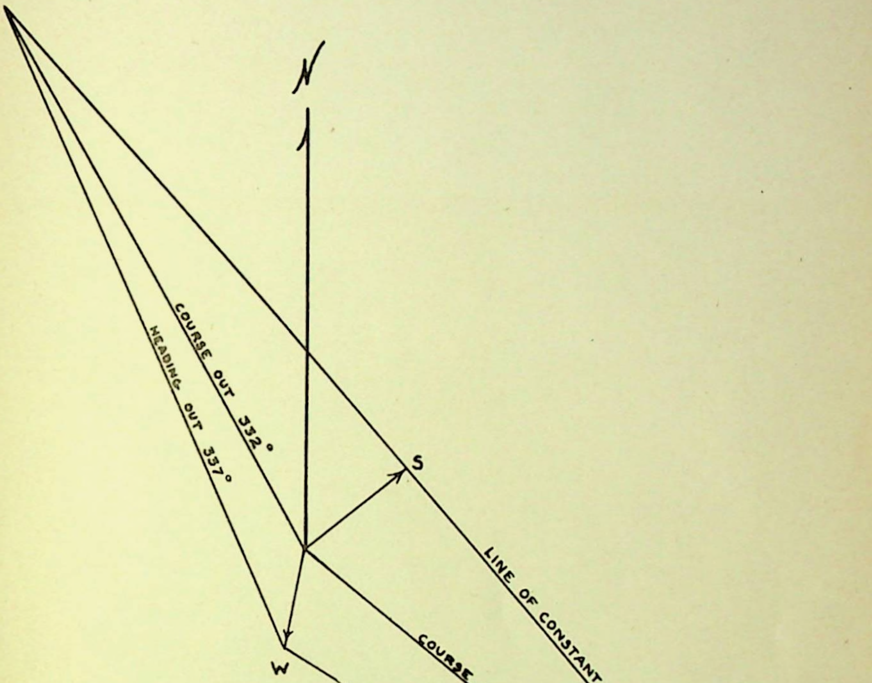
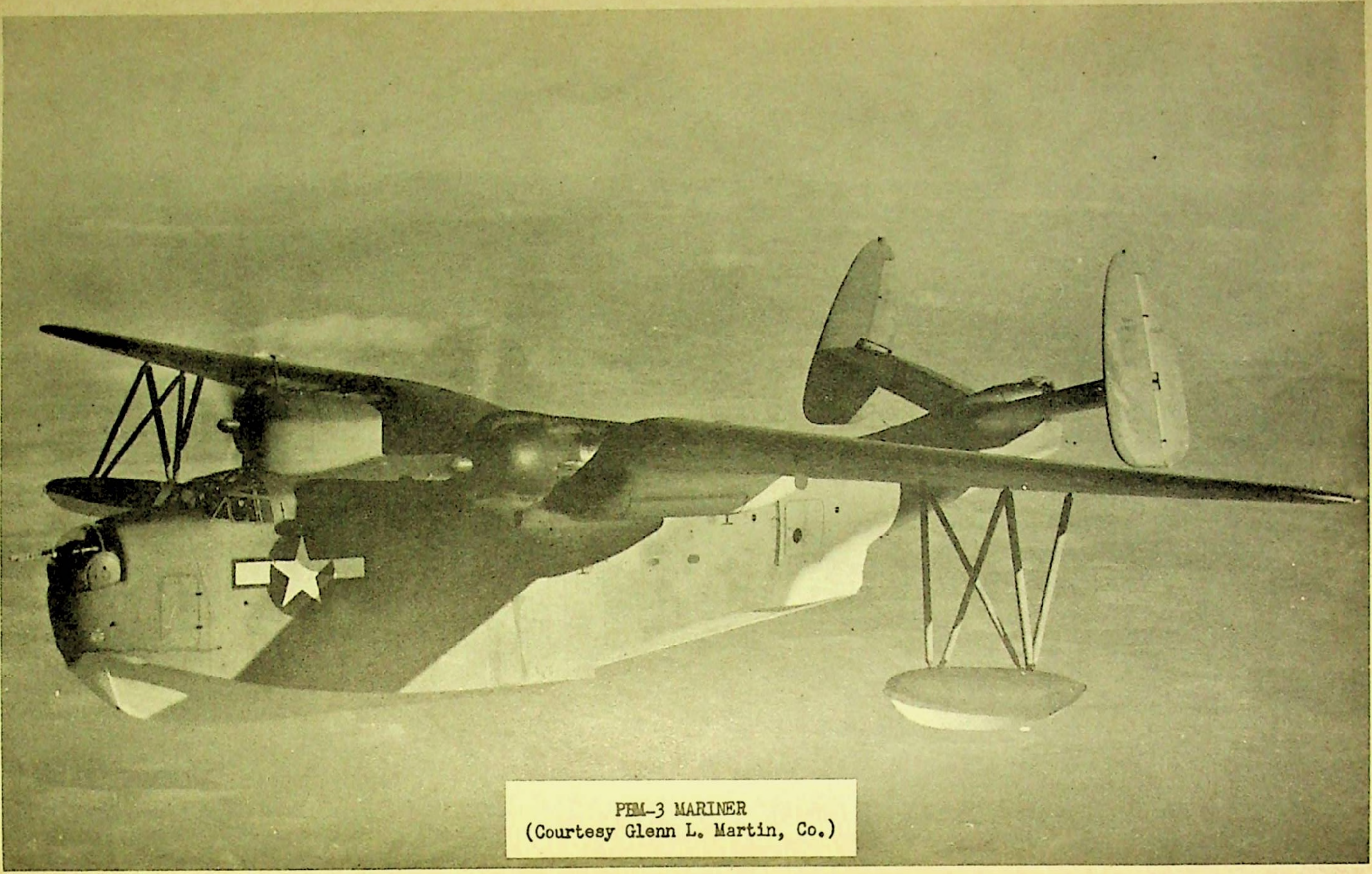


Fig. 32-D



Graphic Solution, Relative Search



PBM-3 MARINER
(Courtesy Glenn L. Martin, Co.)

Required: True course and ground speed out.
True heading out.
Time and distance out.
True course and ground speed in.
True heading in.
Rate of departure.
Rate of closure.

99. Given: Ship's course 236 degrees, speed 22 knots.
Plane's true airspeed 146 knots.
Wind 356 degrees at 24 knots.
Net fuel hours, 4½.
Plane is to maintain a true bearing of 200 degrees from the ship.
Required: True course and ground speed out.
True heading out.
Time and distance out.
True course and ground speed in.
True heading in.
Rate of departure.
Rate of closure.

The following problem is a theoretical flight designed to illustrate the procedure that a navigator on a routine mission might be required to follow. As the purpose of this text is to show the use of the E6-B computer only, the problem lacks those parts which, for conformity, would have to be plotted on the Mercator chart. The student who has faithfully worked the problems in this book, should now be able to work the following example (problems 100 through 109), without references, in less than 46 minutes.

100. A routine mission is planned between two towns, Adam and Baker.
Given: True course Adam to Baker 55 degrees.
Distance Adam to Baker 433 nautical miles.
Calibrated airspeed 127 knots.
Cruising altitude 10,000 feet.
Temperature at flight altitude 0 degrees cent.
Estimated wind 303 degrees at 32 knots.
Required: True airspeed. (Ref. page 9, Problem Type I.)
True heading Adam to Baker.
Ground speed Adam to Baker. (Ref. Problem Type II, Page 33.)
Time from Adam to Baker. (Ref. Problem Type II, Page 15 .)

101. Before take off, the navigator works an alternate on Casper, located 271 nautical miles and 210 degrees from Baker. To work this, the navigator must first find the true course and distance from Adam to Casper and the flight fuel time of the plane.
Required: True course Adam to Casper.
Distance Adam to Casper. (Ref. Problem Type I, Page 72.)

102. The plane carries 600 gallons of fuel and uses this fuel at the rate of 120 gallons per hour.
Required: The total fuel hours available. (Ref. Problem Type II, Page 18.)

103. The required reserve is 25%.
Required: The net fuel hours. (Ref. Problem Type III, Page 26.)

104. The following answers are required on the Alternate Airport problem:
True heading turn to Casper.
Ground speed turn to Casper.
Rate of departure.
Rate of closure.
True course turn to Casper.
Distance Adam to turn.
Time to turn.
Line of constant bearing. (Ref. Page 66, Alternate Airport.)

105. At 1000, the pilot takes off and circles the airport at Adam until flight altitude of 10,000 feet is reached at 1012. Pilot then assumes the heading of 43 degrees for Baker. At 1112 the plane is 10 miles to the left of the original intended true course and 140 miles from Adam. The pilot immediately works a problem to find the wind correction angle and the new true heading to Baker, then turns to this heading.
Required: True heading to Baker. (Ref. Problem Type II, Page 59.)

106. After the turn is made, the navigator works an off-course problem to check the pilots heading, and to find the new wind.
Required: True course Adam to "X".
Ground speed Adam to "X".
New wind.
True course "X" to Baker.
Ground speed "X" to Baker.
Distance "X" to Baker.
Time from "X" to Baker. (Ref. Page 66, Off-Course Problem.)

107. As soon as the off-course problem is solved, the navigator requires the pilot to fly a double drift to check the wind, using an on-course heading of 49 degrees.
Given: On-course drift, 8 degrees right.
Right leg drift, 7½ degrees right.
Left leg drift, 3 degrees right.
Required: Wind from double drift. (Ref. Page 39, Problem Type I.)

108. At approximately 1200 a radio message is received ordering the plane to intercept a strange vessel. The navigator plans to begin the interception at 1215, allowing 15 minutes to work the problem, and finds that at that time the ship will bear 135 degrees from the plane at a distance of 230 nautical miles, on a course of 352 degrees at a speed of 30 knots.
Required: True heading to interception.
True course to interception.
Ground speed to interception.
Rate of closure.
Time to interception. (Ref. Page 60, Interception.)

109. At 1328 the plane intercepts the ship and circles until the vessel indentifies itself as neutral. At that time the true course to Baker is 353 degrees, and the distance 208 nautical miles.
Required: True heading to Baker.
Ground speed to Baker. (Ref. Problem Type II, Page 33.)
Time to Baker. (Ref. Page 15, Problem Type II.)
The plane arrives over Baker at the navigator's ETA, checks with the control tower, and lands, with the routine mission accomplished without mishap.

ADDITIONAL PROBLEMS FOR PRACTICE

Required: Fill in the blanks.

	Ground Speed	Time	Distance
110.	120 knots	1:15	150
111.	105 knots	52 min.	91
112.	145 knots	1:33	225
113.	168 knots	1:40	278
114.	152 knots	35 min.	89
115.	110 m.p.h.	1:22	150 -
116.	133 m.p.h.	2:15	299
117.	108 m.p.h.	2:02	219
118.	210 m.p.h.	48 min.	168
119.	183 m.p.h.	1:25	260
120.	184 knots	20	62 n.m.
121.	108 knots	2:29	268 n.m.
122.	165 knots	.....	100 n.m.
123.	198 knots	1:17	202 n.m.
124.	87 knots	1:28	127 n.m.
125.	208 m.p.h.	30"	104 s.m.
126.	122 m.p.h.	4:49	583 s.m.
127.	346 m.p.h.	37	213 s.m.
128.	56 m.p.h.	5:20	298 s.m.
129.	100 m.p.h.	2:[illegible]	250 s.m.
130.	.....	45 min.	68 s.m.
131.	.....	1:48	204 s.m.
132.	.....	2:02	400 s.m.
133.	.....	1:35	108 s.m.
134.	.....	28 min.	96 s.m.
135.	.....	13 min.	26 n.m.
136.	.....	1:47	356 n.m.
137.	.....	2:03	457 n.m.
138.	.....	1:04	203 n.m.
139.	.....	58 min.	108 n.m.
140.	116 m.p.h.	1:04	.....
141.	156 m.p.h.	53 min.	.....
142.	209 m.p.h.	1:56	.....
143.	98 m.p.h.	2:54	.....
144.	358 m.p.h.	4:59	.....
145.	122 knots	47 min.	.....
146.	330 knots	1:13	.....
147.	98 knots	2:56	.....
148.	106 knots	3:26	.....
149.	208 knots	1:37	.....
150.	129 m.p.h.	.....	28 s.m.
151.	116 m.p.h.	.....	13½ s.m.
152.	220 m.p.h.	.....	66 s.m.
153.	192 m.p.h.	.....	16 s.m.
154.	157 m.p.h.	.....	21 s.m.
155.	175 knots	.....	500 n.m.
156.	149 knots	.....	144 n.m.
157.	118 knots	.....	124 n.m.
158.	137 knots	.....	183 n.m.
159.	102 knots	.....	7.64 n.m.
160.	.....	2:34	930 s.m.
161.	.....	5M 24S	20 s.m.
162.	.....	1:40	248 s.m.
163.	.....	48 min.	80 s.m.
164.	.....	1:17	140 s.m.
165.	.....	10:00	1000 n.m.
166.	.....	1:23	385 n.m.
167.	.....	40 min.	125½ n.m.

ADDITIONAL PROBLEMS FOR PRACTICE

Required: Fill in the blanks.

	Ground Speed	Time	Distance
168.	.....	6:40	660 n.m.
169.	.....	1.1 min.	1.56 n.m.

	Statute Miles	Nautical Miles	Kilometers
170.	15	.....	.....
171.	210	.....	.....
172.	14½	.....	.....
173.	178	.....	.....
174.	57	.....	.....
175.	820	.....	.....
176.	95	.....	.....
177.	127	.....	.....
178.	265	.....	.....
179.	38	.....	.....
180.	.....	44¼	.....
181.	.....	650	.....
182.	.....	3.9	.....
183.	.....	800	.....
184.	.....	.126	.....
185.	.....	156	.....
186.	.....	20	.....
187.	.....	26.5	.....
188.	.....	1.67	.....
189.	.....	409	.....
190.	.....	.....	57.6
191.	.....	.....	135
192.	.....	.....	15.5
193.	.....	.....	120.5
194.	.....	.....	184.5
195.	.....	.....	16
196.	.....	.....	20,840
197.	.....	.....	1,521
198.	.....	.....	9.6
199.	.....	.....	111
200.	62	.....	.....
201.	137	.....	.....
202.	356	.....	.....
203.	20.3	.....	.....
204.	122	.....	.....
205.	115	.....	.....
206.	1.36	.....	.....
207.	57.6	.....	.....
208.	2100	.....	.....
209.	.138	.....	.....
210.	.....	306	.....
211.	.....	23.7	.....
212.	.....	164	.....
213.	.....	678	.....
214.	.....	13,340	.....
215.	.....	16.5	.....
216.	.....	115	.....
217.	.....	239	.....
218.	.....	3,670	.....
219.	.....	95	.....
220.	.....	.....	53
221.	.....	.....	678
222.	.....	.....	115
223.	.....	.....	45.6

ADDITIONAL PROBLEMS FOR PRACTICE

Required: Fill in the blanks.

	Statute Miles	Nautical Miles	Kilometers
224.	.....	.....	61
225.	.....	.....	5280
226.	.....	.....	13.4
227.	.....	.....	1.67
228.	.....	.....	897
229.	.....	.....	136

	Pressure Alt.	Temperature	I.A.S.	T.A.S.
230.	10,000 feet	0 deg. C.	178 m.p.h.	.....
231.	15,000	-20	160	.....
232.	12,000	-25	180	.....
233.	8,000	10	164	.....
234.	30,000	10	192	.....
235.	28,000	-40	190	.....
236.	1,000	5	85	.....
237.	4,000	-20	190	.....
238.	5,500	15	135	.....
239.	7,200	22	158	.....
240.	4,000	40	89	.....
241.	3,000	10	77	.....
242.	12,500	-10	103	.....
243.	9,000	-3	120	.....
244.	18,000	-15	134	.....
245.	23,500	-35	174	.....
246.	8,000	5	85	.....
247.	9,500	0	117	.....
248.	3,000	-22	174	.....
249.	30,000	-45	350	.....
250.	1,500	38	122	.....
251.	3,750	22	116	.....
252.	22,500	-34	248	.....
253.	17,000	-24	186	.....
254.	13,500	-3.5	154	.....
255.	11,000	0	122	.....
256.	8,000	1	117	.....
257.	16,400	-11	157	.....
258.	10,000	10	142	.....
259.	6,300	11	178	.....
260.	15,500	-32	.....	346 m.p.h.
261.	13,000	-20	.....	136
262.	10,500	-10	.....	134
263.	11,450	-2	.....	178
264.	8,000	-9	.....	124
265.	4,500	22	.....	145
266.	5,000	30	.....	110
267.	2,500	40	.....	120
268.	3,000	35	.....	154
269.	5,500	20	.....	124
270.	22,000	-33	.....	256
271.	30,000	-45	.....	422
272.	19,000	-23	.....	222
273.	11,500	-12	.....	203
274.	10,000	0	.....	164
275.	12,000	-9	.....	120
276.	7,500	16	.....	167
277.	4,000	15	.....	145
278.	2,000	20	.....	200
279.	1,670	16	.....	135

ADDITIONAL PROBLEMS FOR PRACTICE

Required: Fill in the blanks.

	Pressure Alt.	Temperature	I.A.S.	T.A.S.
280.	28,000 feet	-38	.....	278
281.	16,000	-27	.....	210
282.	12,500	-14	.....	184
283.	16,000	-16	.....	160
284.	1,000	40	.....	138
285.	2,750	38	.....	110
286.	30,000	-40	.....	456
287.	13,500	-28	.....	190
288.	4,500	0	.....	157
289.	2,000	20	.....	200

Required: Find the Radius of Action and the time to turn on the following problems, given:

	Ground Speed Out	Ground Speed Back	N.F.H.
290.	116 m.p.h.	164 m.p.h.	4½
291.	186 m.p.h.	122 m.p.h.	6
292.	90 knots	134 knots	3
293.	148 knots	97 knots	3.6
294.	130 knots	195 knots	6.5
295.	122 knots	178 knots	5
296.	100 m.p.h.	200 m.p.h.	4
297.	168 m.p.h.	160 m.p.h.	3
298.	130 m.p.h.	150 m.p.h.	2½
299.	167 knots	125 knots	6
300.	220 m.p.h.	178 m.p.h.	7
301.	134 m.p.h.	168 m.p.h.	4
302.	67 m.p.h.	99 m.p.h.	8
303.	118 m.p.h.	122 m.p.h.	7
304.	189 m.p.h.	113 m.p.h.	6
305.	160 knots	159 knots	3.8
306.	122 m.p.h.	133 m.p.h.	4.7
307.	354 knots	422 knots	5.3
308.	166 knots	122 knots	3.3
309.	101 m.p.h.	121 m.p.h.	2.6

	S1	S2	GS1	N.F.H.
310.	146 knots	124 knots	123 knots	4½
311.	133 knots	145 knots	189 knots	3.3
312.	36 m.p.h.	122 m.p.h.	145 m.p.h.	4
313.	108 m.p.h.	149 m.p.h.	167 m.p.h.	5
314.	126 knots	189 knots	122 knots	6½
315.	118 knots	128 knots	136 knots	5½

316. True course out of 359 degrees, true airspeed of 368 knots, wind of 237 degrees at 37 knots, and 6¼ N.F.H.

317. True course out of 45 degrees, true airspeed of 150 m.p.h., wind of 65 degrees at 30 m.p.h., and 4½ N.F.H.

318. True course out of 300 degrees, true airspeed of 124 knots, wind of 50 degrees at 26 knots, and 4.7 N.F.H.

319. True course out of 45 degrees, true airspeed of 110 knots, wind of 320 degrees at 20 knots, and 4 net fuel hours.

320. True course out of 57 degrees, true airspeed of 110 m.p.h., wind from 342 degrees at 30 m.p.h., and 3.75 net fuel hours.

321. True airspeed of 140½ m.p.h., true course out of 235 degrees, wind from 180 degrees at 30 m.p.h., and 9 net fuel hours.

ADDITIONAL PROBLEMS FOR PRACTICE

Required: Find the Radius of Action and the time to turn on the following problems, given:

322. True course out of 185 degrees, true airspeed of 156½ m.p.h., wind from 27 degrees at 25 m.p.h., and 4 net fuel hours.
323. True course out of 143 degrees, true airspeed of 140½ m.p.h., wind of 30 degrees at 30 m.p.h., and 3 net fuel hours.
324. True course out of 345 degrees, true airspeed of 230 knots, wind of 116 degrees at 23 knots, and 5 net fuel hours.
325. True course out of 163 degrees, true airspeed of 98 m.p.h., wind of 201 degrees at 46 m.p.h., and 9.5 net fuel hours.

Required: Fill in the blanks

	T.H.	T.A.S.	T.C.	G.S.	Wind D/F
326.	162 deg.	132 kts.	.....	.....	320/16
327.	36	168	.....	.....	135/23
328.	347	128	.....	.....	110/34
329.	122	100	.....	.....	35/35
330.	236	137	.....	.....	345/26
331.	122	139	.....	.....	119/21
332.	189	214	.....	.....	16/11
333.	122	316	.....	.....	256/34
334.	56	114	.....	.....	116/46
335.	108	108	.....	.....	180/18
336.	189	146	.....	.....	360/21
337.	356	213	.....	.....	101/13
338.	89	103	.....	.....	267/26
339.	112	235	.....	.....	116/13
340.	167	126	.....	.....	346/24
341.	.....	.....	153 deg.	113 m.p.h.	222/22
342.	.....	.....	189	214	124/17
343.	.....	.....	239	187	46/34
344.	.....	.....	162	102	111/11
345.	.....	.....	347	168	137/17
346.	.....	.....	002	118	352/23
347.	.....	.....	046	137	119/33
348.	.....	.....	305	129	54/26
349.	.....	.....	107	143	187/25
350.	.....	.....	167	102	349/33
351.	.....	.....	216	202	121/30
352.	.....	.....	111	97	183/22
353.	.....	.....	271	174	192/19
354.	.....	.....	001	203	122/29
355.	.....	.....	083	143	138/27
356.	.....	136 m.p.h.	163 deg.	.....	165/24
357.	.....	199	222	.....	104/29
358.	.....	208	161	.....	218/36
359.	.....	309	298	.....	132/46
360.	.....	122	009	.....	090/15
361.	.....	239	036	.....	267/27
362.	.....	162	162	.....	162/16
363.	.....	119	137	.....	351/19
364.	.....	139	317	.....	221/30
365.	.....	183	213	.....	114/26
366.	.....	171	227	.....	213/29
367.	.....	196	305	.....	098/28
368.	.....	209	300	.....	123/22
369.	.....	163	122	.....	347/27
370.	.....	356	267	.....	119/21
371.	100 deg.	122 m.p.h.	104 deg.	116 m.p.h.	.....

ADDITIONAL PROBLEMS FOR PRACTICE

Required: Fill in the blanks

	T.H.	T.A.S.	T.C.	G.S.	Wind D/F
372.	165	208	167	234	.....
373.	122	305	126	305	.....
374.	315	134	322	140	.....
375.	236	163	222	158	.....
376.	266	100	266	100	.....
377.	119	203	122	217	.....
378.	198	137	209	146	.....
379.	209	168	215	179	.....
380.	313	300	315	300	.....
381.	287	149	296	152	.....
382.	197	306	199	315	.....
383.	218	166	222	173	.....
384.	157	133	148	147	.....
385.	233	198	237	184	.....

Required: The wind on the following drift problems.

	T.A.S.	T.H.	O.C.D.	R.L.D.	L.L.D.
386.	190 kts.	40 deg.	8 Right	8½ R	1 R
387.	224	332	6½ Left	1 R	9 L
388.	230	100	1 L	3 L	1 R
389.	130	286	12½ L	13 L	6½ L
390.	90	62	2½ L	18 L	12 R
391.	345	315	4 L	1 L	4 L
392.	150	304	6½ R	10 R	2 L
393.	190	211	6½ R	5 R	4 R
394.	225	347	7½ L	8 L	3 L
395.	140	54	2 R	0	2½ R
396.	154	115	12 L	3½ L	12½ L
397.	300	300	6 L	4½ L	4 L
398.	105	299	13½ R	13½ R	1 R
399.	110	10	29½ R	22½ R	15 R
400.	139	336	3 L	11 L	6 R
401.	150	67	1 L	6 L	5 R
402.	158	317	2½ R	10 R	7 L
403.	145	228	2 L	6 L	3 R
404.	180	14	4 R	12 R	6 L
405.	157	264	6 L	3 R	10 L
406.	160	151	1 L	8 L	6 R
407.	148	98	5 R	0	8 R
408.	162	116	0	0	0
409.	158	281	1 L	2½ L	1 R
410.	187	352	3 R	15 R	12 L

	T.A.S.	T.H.	Drift	T.H.	Drift
411.	170 m.p.h.	32 deg.	6 Right	72 deg.	10 R
412.	175	184	4 L	96	3 R
413.	247	125	2 R	216	7 R
414.	82	291	24 R	62	24 L
415.	150	33	7 L	5	5 L
416.	170	18	13 R	342	0
417.	196	347	3 R	259	1 L
418.	200	107	4 L	61	3 R
419.	174	25	3 L	352	5 L
420.	146	2	13 R	85	13 R

ADDITIONAL PROBLEMS FOR PRACTICE

MULTIPLICATION

421. Multiply 16 by 23.
422. Multiply 18.2 by 533.
423. Multiply 1330 by 236.
424. Multiply 1.38 by 2.02.
425. Multiply .396 by .8760.
426. Multiply 24 by 86.
427. Multiply 2.4 by 8.6.
428. Multiply 2.4 by 86.
429. Multiply .24 by .860.
430. Multiply 132 by 18.6.

DIVISION

431. Divide 26400 by 132.
432. Divide 1292 by 3.230.
433. Divide 18750 by 62.50.
434. Divide .0386 by .140.
435. Divide 368 by 23.

Required: On the following off-course problems find the new wind, the true heading "X" to "B", the ground speed "X" to "B", and the time "X" to "B".

436. Given: True course "A" to "B" 183 degrees, distance "A" to "B" 188 miles. True airspeed 135 miles per hour, and no estimated wind. At the end of ½ hour the pilot finds himself 6 miles to the right of the original intended true course and 75 miles from "A".

437. Given: True course "A" to "B" 60 degrees, distance "A" to "B" 274 miles. True airspeed 185 miles per hour, and an estimated wind from 300 degrees at 25 miles per hour. At the end of ½ hour the pilot finds himself 4 miles to the right of the original true course and 85 miles from "A".

438. Given: True course "A" to "B" 170 degrees, distance "A" to "B" 165 nautical miles. Estimated wind is from 290 degrees at 20 knots. At the end of ½ hour the pilot finds himself 11 miles to the left of the original true course and 65 miles from "A". The true airspeed is 152½ knots.

439. Given: True course "A" to "B" 293 degrees, distance "A" to "B" 230 miles. True airspeed 135 miles per hour, and no estimated wind. At the end of ½ hour the plane is 5½ miles to the left of the intended true course and 60 miles from "A".

440. Given: True course "A" to "B" 305 degrees, distance "A" to "B" 200 nautical miles. True airspeed is 154 knots, and estimated wind from 5 degrees at 25 knots. At the end of ½ hour the pilot finds himself over a check point 4 miles to the right of the course and 50 miles from "A".

441. Given: True course "A" to "B" 265 degrees, distance "A" to "B" 300 miles. True airspeed 138 miles per hour, and estimated wind from 15 degrees at 34 miles per hour. At the end of 1 hour the pilot finds himself 8 miles to the right of the intended true course and 150 miles from "A".

442. Given: True course "A" to "B" 13 degrees, distance "A" to "B"

ADDITIONAL PROBLEMS FOR PRACTICE

350 nautical miles. True airspeed 168 knots, and estimated wind from 320 degrees at 33 knots. At the end of 1 hour, the pilot finds himself 6 miles to the right of the intended true course and 144 miles from "A".

443. Given: True course "A" to "B" 357 degrees, distance "A" to "B" 230 nautical miles. True airspeed 180 knots, and estimated wind from 273 degrees at 32½ knots. At the end of ½ hour the pilot finds himself 4 miles to the right of the intended true course and 80 miles from "A".

444. Given: True course "A" to "B" 76 degrees, distance "A" to "B" 200 miles. True airspeed 110 miles per hour, and no estimated wind. At the end of 1 hour the plane is 10 miles to the left of the intended course and 96 miles from "A".

445. Given: True course "A" to "B" 28 degrees, distance "A" to "B" 168 miles. True airspeed 156 miles per hour, and estimated wind from 208 degrees at 20 miles per hour. At the end of ½ hour the plane is 6 miles to the right of the intended true course and 70 miles from "A".

446. Given: True course "A" to "B" 265 degrees,
Distance "A" to "B" 620 statute miles,
True course "A" to "C" 240 degrees,
Distance "A" to "C" 480 statute miles,
Net fuel hours, 6.
Wind from 315 degrees at 28 miles per hour,
True airspeed 150 miles per hour.
Required: True heading and ground speed "A" to "B",
True course, true heading, and ground speed "X" to "C",
Rate of departure and rate of closure,
Radius of action and time from "A" to "X".

447. Given: True course "A" to "B" 170 degrees,
Distance "A" to "B" 475 statute miles,
True course "A" to "C" 205 degrees,
Distance "A" to "C" 266 statute miles,
Net fuel hours, 4½.
Wind from 75 degrees at 30 miles per hour,
True air speed 160 miles per hour.
Required: True heading and ground speed "A" to "B",
True course, true heading, and ground speed "X" to "C",
Rate of departure and rate of closure,
Radius of action and time from "A" to "X".

448. Given: True course "A" to "B" 200 degrees,
Distance "A" to "B" 1268 nautical miles,
True course "A" to "C" 218 degrees,
Distance "A" to "C" 468 nautical miles,
Net fuel hours, 9.
Wind from 273 degrees at 30 knots,
True airspeed 202 knots.
Required: True heading and ground speed "A" to "X",
True course, true heading, and ground speed "X" to "C",
Rate of departure and rate of closure,
Radius of action and the time from "A" to "X".

449. Given: True course "A" to "B" 115 degrees,

Distance "A" 525 statute miles,
True course "A" to "C", 132 degrees,
Distance "A" to "C" 250 statute miles,
Net fuel hours, 5.
Wind from 60 degrees at 24 miles per hour,
True airspeed 165 miles per hour.
Required: True heading and ground speed "A" to "X",
True heading, true course, and ground speed "X" to "C",
Distance "X" to "C",
Rate of departure and rate of closure,
Radius of action and time from "A" to "X".

450. Given: True course "A" to "B" 87 degrees,
Distance "A" to "B" 656 nautical miles,
True course "A" to "C" 78 degrees,
Distance "A" to "C" 600 nautical miles,
Net fuel hours, 4.
Wind from 109 degrees at 28 knots,
True airspeed 196 knots.
Required: True heading and ground speed "A" to "B",
True heading, true course and ground speed "X" to "C",
Time and distance "X" to "C",
Radius of action and time "A" to "X".

451. Given: True course "A" to "B" 343 degrees,
Distance "A" to "B" 562 statute miles,
True course "A" to "C" 329 degrees,
Distance "A" to "C" 230 statute miles.
Net fuel hours, 5.
Wind from 34 degrees at 22 miles per hour.
True airspeed 158 miles per hour.
Required: True heading and ground speed "A" to "B".
True heading, true course, distance, ground speed and time, "X" to "C"; Radius of Action and time "A" to "X".

452. A plane takes off to intercept a ship reported on a true course of 265 degrees at a speed of 24 knots. At the time of take-off, the ship bears 65 degrees from the plane, at a distance of 206 miles. The true airspeed of the plane is 162 knots, and the wind is 322 degrees at 23 knots. Find the true heading, the true course, ground speed and rate of closure to interception, and the time of interception.

453. A plane takes off to intercept a vessel reported on a true course of 181 degrees at a speed of 36 knots. Bearing from the plane at take-off is 232 degrees and distance 119 miles. True airspeed is 186 knots and the wind is from 63 degrees at 28 knots. Find the time to interception and the interception heading.

454. A plane takes off to intercept a ship bearing 122 degrees and 438 miles from the departure point. The ship is on a true course of 360 degrees at a speed of 28 knots. The true airspeed of the plane is 132 knots and the wind is from 62 degrees at 20 knots. Find the true course, ground speed, and time to interception.

455. A plane takes off to intercept a vessel reported on a true course of 287 degrees at a speed of 16 knots. Wind is from 331 degrees at 24 knots, and the true airspeed of the plane is 158 knots.

ADDITIONAL PROBLEMS FOR PRACTICE

Bearing of the ship from the plane, at take-off, is 100 degrees and 86 miles away. Find true heading and time to interception.

456. At 0900 a plane takes off to intercept a vessel 215 miles away on a bearing of 167 degrees. True airspeed 175 knots, wind 22 degrees at 32 knots. Ships' course 5 degrees at 20 knots. Find true heading and time to interception.

457. A plane takes off to intercept a ship reported on a true course of 123 degrees at a speed of 31 knots. Bearing of the ship from departure is 162 degrees, distance 323 miles. True airspeed of the plane is 120 knots, and the wind is from 260 degrees at 30 knots. Find the true heading, ground speed, and time to interception.

ANSWERS
EXAMPLES FOR PRACTICE

Problem	
1	127 Statute Miles, 204 Kilometers.
2	285 miles per hour.
3	61 kilometers.
4	20 nautical miles, 37 kilometers.
5	73 knots.
6	289 kilometers.
7	210 knots.
8	200 knots.
9	210 knots.
10	189 miles per hour.
11	300 knots.
12	244 miles per hour.
13	415 knots.
14	16,350 feet.
15	18,600 feet.
16	32,400 feet.
17	10,900 feet.
18	31,000 feet.
19	105 miles per hour.
20	153 miles per hour.
21	157½ miles per hour.
22	48 minutes.
23	1 hour, 45 minutes.
24	1 hour, 17 minutes.
25	930 nautical miles.
26	28 statute miles.
27	45 nautical miles.
28	55½ gallons per hour.
29	90 gallons per hour.
30	208 gallons per hour.
31	4 hours, 12 minutes.
32	5 hours.
33	4 hours, 52 minutes.
34	63 gallons.
35	200 gallons.
36	95 gallons.
37	2392.
38	5146.
39	1854.
40	148.68.
41	12.7.
42	0.21.
43	12.1.
44	362 nautical miles, radius of action 2 hours, 22 minutes, time out.
45	285 statute miles, radius of action 1 hour, 35 minutes, time out.
46	695 nautical miles, radius of action 5 hours, 10 minutes, time out.
47	164 nautical miles, radius of action 57 minutes, time out.
48	87 knots.
49	237 miles per hour.
50	38.5 minutes.
51	48 minutes.
52	45/100.
53	30/100.
54	5.25 hours.
55	7.125 hours.

ANSWERS
EXAMPLES FOR PRACTICE

Problem
56..............88½ degrees true course, 104 miles per hour ground speed.
57..............290 degrees true course, 270 knots ground speed.
58..............15 degrees true course, 266 miles per hour ground speed.
59..............9½ degrees true course, 163 knots ground speed.
60..............329½ degrees true heading, 177 miles per hour ground speed.
61..............300 degrees true heading, 159 knots ground speed.
62..............99 degrees true heading, 189½ miles per hour ground speed.
63..............12 degrees true heading, 168 miles per hour ground speed.
64..............64½ degrees true heading, 153 knots true air speed.
65..............353 degrees true heading, 145 knots true air speed.
66..............147 degrees true heading, 174½ knots true air speed.
67..............40 degrees true heading, 156½ knots true air speed.
68..............116 degrees at 20 knots.
69..............43 degrees at 9 miles per hour.
70..............140 degrees at 25 knots.
71..............58 degrees at 34 knots.
72..............273 degrees at 23 miles per hour.
73..............283 degrees at 35 knots.
74..............281 degrees at 12 miles per hour.
75..............64 degrees at 44 knots.
76..............132 degrees at 25½ miles per hour.
77..............110 miles per hour ground speed out.
145 miles per hour ground speed in.
244 degrees true heading out.
42 degrees true heading in.
1 hour 59 minutes time out.
218 statute miles radius of action.
78..............171 knots ground speed out.
170 knots ground speed in.
170½ degrees true heading out.
5 degrees true heading in.
1 hour 22 minutes time out.
234 nautical miles radius of action.
79..............96 miles per hour ground speed out.
121 miles per hour ground speed in.
338 degrees true heading out.
142 degrees true heading in.
3 hours 20 minutes 30 seconds time out.
321 statute miles radius of action.
80..............278 degrees true heading "A" to "B".
268 degrees true course "A" to "X".
262 degrees true course "X" to "B".
28 degrees at 28 miles per hour new wind.
271 degrees true heading "X" to "B".
153 miles per hour ground speed "X" to "B".
150 statute miles distance "X" to "B".
59 minutes time "X" to "B".
81..............188 degrees true course "A" to "X".
179 degrees true heading "A" to "X".
144 miles per hour ground speed "A" to "X".
60 degrees at 26 miles per hour new wind.
188 degrees true heading "X" to "B".
147 miles per hour ground speed "X" to "B".
113 statute miles distance "X" to "B".
46 minutes time "X" to "B".

ANSWERS
EXAMPLES FOR PRACTICE

Problem	
82	279 degrees true heading "A" to "X".
	283 degrees true course "A" to "X".
	112 knots ground speed "A" to "X".
	137 degrees at 12 knots new wind.
	268 degrees true heading "X" to "B".
	273 degrees true course "X" to "B".
	110 knots ground speed "X" to "B".
	83 nautical miles distance "X" to "B".
	45 minutes 30 seconds time "X" to "B".
83	102 degrees.
84	274 degrees.
85	129 knots, rate of interception.
	29½ degrees true heading.
	110 knots ground speed.
	19 degrees true course.
	1 hour 33 minutes time to interception.
86	151 knots rate of interception.
	193½ degrees true course.
	157 knots ground speed.
	187 degrees true heading.
	2 hours 12 minutes time to interception.
87	294 knots rate of interception.
	269 degrees true course.
	274 degrees true heading.
	294 knots ground speed.
	1 hour 38 minutes time to interception.
88	307 degrees true heading out.
	171 miles per hour ground speed out.
	163½ degrees true course in.
	168 degrees true heading in.
	149 miles per hour ground speed in.
	139 miles per hour rate of departure.
	171 miles per hour rate of closure.
	565 miles radius of action.
	401 miles distance "X" to "C".
	3 hours 18 minutes time out.
	2 hours 42 minutes time in.
	148 degrees bearing.
89	204 degrees true course in.
	75½ degrees true heading out.
	205 degrees true heading in.
	120 miles per hour ground speed out.
	73 miles per hour ground speed in.
	81 miles per hour rate of departure.
	99 miles per hour rate of closure.
	2 hours 44 minutes time out.
	2 hours 16 minutes time in.
	328 miles radius of action.
	178 miles distance "X" to "C".
90	348 degrees true course in.
	358 degrees true heading in.
	148 degrees true heading out.
	146 knots ground speed out.
	133 knots ground speed in.
	160 knots rate of closure.
	119 knots rate of departure.
	335 nautical miles radius of action.
	226 nautical miles distance "X" to "C".
	2 hours 18 minutes time out.

ANSWERS
EXAMPLES FOR PRACTICE

Problem
90(continued)..1 hour 42 minutes time in.
343 degrees bearing.
91.............288½ degrees true course.
507 miles distance.
92.............358 degrees true course.
885 miles distance.
93.............180 degrees true course.
632 miles distance.
94.............74 degrees true heading "A" to "X".
140 miles per hour ground speed "A" to "X".
286 miles distance "A" to "X" (Radius of Action).
2 hours 3 minutes time "A" to "X".
243 degrees true heading "X" to "C".
57 minutes time "X" to "C".
99 miles per hour ground speed "X" to "C".
95 miles distance "X" to "C".
95.............252½ degrees true heading "A" to "X".
146 miles per hour ground speed "A" to "X".
360 miles distance "A" to "X".
2 hours 28 minutes time "A" to "X".
108 degrees true heading "X" to "C".
116 degrees true course "X" to "C".
32 minutes time "X" to "C".
154 miles per hour ground speed "X" to "C".
84 miles distance "X" to "C".
96.............60 degrees true heading "A" to "X".
132 miles per hour ground speed "A" to "X".
534 miles distance "A" to "X".
4 hours 3 minutes time "A" to "X".
177 degrees true heading "X" to "C".
173 degrees true course "X" to "C".
57 minutes time "X" to "C".
142 miles distance "X" to "C".
149½ miles per hour ground speed "X" to "C".
97.............30 degrees true course out.
123 knots ground speed out.
41 degrees true heading out.
1 hour 53 minutes time out.
232 nautical miles radius of action.
229 degrees true course in.
140 knots ground speed in.
219 degrees true heading in.
97 knots rate of departure.
163 knots rate of closure.
98.............225½ degrees true course out.
143½ knots ground speed out.
215 degrees true heading out.
2 hours 23 minutes time out.
342 nautical miles distance out.
69½ degrees true course in.
74½ degrees true heading in.
97 knots ground speed in.
123 knots rate of departure
112 knots rate of closure.
99.............204½ degrees true course out.
166½ knots ground speed out.
209 degrees true heading out.
2 hours 11 minutes time out.
365 nautical miles distance out.

ANSWERS
EXAMPLES FOR PRACTICE

Problems	
99(continued)	14½ degrees true course in. 123 knots ground speed in. 10½ degrees true heading in. 148 knots rate of departure. 140 knots rate of closure.
100	43 degrees true heading Adam to Baker. 159 knots ground speed Adam to Baker. 150 knots true airspeed. 2 hours 43 minutes 30 seconds time Adam to Baker.
101	88 degrees true course Adam to Casper. 218 nautical miles distance Adam to Casper.
102	5 hours total fuel available.
103	3 hours 45 minutes net fuel hours.
104	214 degrees true heading turn to Casper. 153 knots ground speed turn to Casper. 116 knots rate of departure. 183 knots rate of closure. 202 degrees true course turn to Casper. 365 nautical miles distance Adam to turn. 223 nautical miles distance turn to Casper. 2 hours 17 minutes 30 seconds time to turn. 219 degrees line of constant bearing.
105	49 degrees true heading to Baker.
106	51 degrees true course Adam to "X". 345 degrees new wind direction. 22 knots new wind force. 57 degrees true course "X" to Baker. 49 degrees true heading "X" to Baker. 142 knots ground speed "X" to Baker. 293 nautical miles distance "X" to Baker. 2 hours 4 minutes time "X" to Baker.
107	346 degrees at 22 knots.
108	129 degrees true course. 124 degrees true heading. 167 knots ground speed. 190 knots rate of closure. 1 hour 12 minutes 30 seconds time to interception.
109	352 degrees true heading to Baker. 129 knots ground speed to Baker. 1 hour 37 minutes time to Baker.
110	150 nautical miles.
111	91 nautical miles.
112	225 nautical miles.
113	280 nautical miles.
114	88½ nautical miles.
115	150 miles.
116	300 miles.
117	220 miles.
118	168 miles.
119	260 miles.
120	20.3 minutes.
121	2 hours, 29 minutes.
122	36.5 minutes.
123	1 hour 1 minute.
124	1 hour, 27 minutes, 30 seconds.
125	30 minutes.
126	4 hours, 48 minutes.
127	37 minutes.
128	5 hours, 20 minutes.

ANSWERS
EXAMPLES FOR PRACTICE

Problem	
129	2 hours, 30 minutes.
130	91 miles per hour.
131	113 miles per hour.
132	197 miles per hour.
133	68 miles per hour.
134	206 miles per hour.
135	120 knots.
136	200 knots.
137	223 knots.
138	190 knots.
139	112 knots.
140	123½ statute miles.
141	138 statute miles.
142	404 statute miles.
143	284 statute miles.
144	1780 statute miles.
145	95 nautical miles.
146	401 nautical miles.
147	287 nautical miles.
148	364 nautical miles.
149	336 nautical miles.
150	13 minutes.
151	7 minutes.
152	18 minutes.
153	5 minutes.
154	8 minutes.
155	2 hours, 51 minutes.
156	58 minutes.
157	1 hour, 3 minutes.
158	1 hour, 20 minutes.
159	4½ minutes.
160	362 miles per hour.
161	222 miles per hour.
162	149 miles per hour.
163	100 miles per hour.
164	109 miles per hour.
165	100 knots.
166	278 knots.
167	188 knots.
168	99 knots.
169	85 knots.
170	13 nautical miles, 24 kilometers.
171	182 n.m., 337 km.
172	12.6 n.m., 23.2 km.
173	154 n.m., 285½ km.
174	49½ n.m., 91½ km.
175	710 n.m., 1315 km.
176	82½ n.m., 152 km.
177	110 n.m., 204 km.
178	230 n.m., 425 km.
179	33 n.m., 61 km.
180	51 statute miles, 82 kilometers.
181	750 s.m., 1202 km.
182	4½ s.m., 7.2 km.
183	921 s.m., 1480 km.
184	0.145 s.m., 0.232 km.
185	180 s.m., 289 km.
186	23 s.m., 37 km.
187	30½ s.m., 49 km.

ANSWERS
EXAMPLE FOR PRACTICE

Problems	
188	1.92 s.m., 308 km.
189	470 s.m., 751 km.
190	36 statute miles, 31.2 nautical miles.
191	84 s.m., 73 n.m.
192	9.7 s.m., 8.4 n.m.
193	75 s.m., 65 n.m.
194	115 s.m., 100 n.m.
195	10 s.m., 8.7 n.m.
196	13,000 s.m., 11,300 n.m.
197	950 s.m., 823 n.m.
198	6 s.m., 5.2 n.m.
199	69 s.m., 60 n.m.
200	54 nautical miles, 99 kilometers.
201	119 n.m., 220 km.
202	310 n.m., 570 km.
203	17.6 n.m., 32.5 km.
204	106 n.m., 196 km.
205	100 n.m., 184½ km.
206	1.18 n.m., 2.18 km.
207	50 n.m., 92½ km.
208	1820 n.m., 3370 km.
209	0.120 n.m., .221 km.
210	353 statute miles, 565 kilometers.
211	27.4 s.m., 43.8 km.
212	189 s.m., 303 km.
213	780 s.m., 1250 km.
214	15,400 s.m.,24,620 km.
215	19 s.m., 30.5 km.
216	132½ s.m., 212½ km.
217	276 s.m., 441 km.
218	4,240 s.m., 6,780 km.
219	109½ s.m., 176 km.
220	28.7 nautical miles, 33 statute miles.
221	367 n.m., 424 s.m.
222	62 n.m., 72 s.m.
223	24.7 n.m., 28.5 s.m.
224	33 n.m., 38 s.m.
225	2860 n.m., 3300 s.m.
226	7.23 n.m., 8.32 s.m.
227	0.9 n.m., 1.04 s.m.
228	485 n.m., 560 s.m.
229	73.7 n.m., 85 s.m.
230	210 miles per hour, true airspeed.
231	200 m.p.h.
232	210 m.p.h.
233	189 m.p.h.
234	350 m.p.h.
235	300 m.p.h.
236	85 m.p.h.
237	192 m.p.h.
238	150 m.p.h.
239	184 m.p.h.
240	100 m.p.h.
241	81 m.p.h.
242	125 m.p.h.
243	138 m.p.h.
244	180 m.p.h.
245	252 m.p.h.
246	97 m.p.h.

ANSWERS
EXAMPLES FOR PRACTICE

Problem	
247	137 m.p.h.
248	172 m.p.h.
249	574 m.p.h.
250	131 m.p.h.
251	126 m.p.h.
252	353 m.p.h.
253	240 m.p.h.
254	195 m.p.h.
255	147 m.p.h.
256	133 m.p.h.
257	206 m.p.h.
258	170 m.p.h.
259	199 m.p.h.
260	280 miles per hour, indicated airspeed.
261	113 m.p.h.
262	115 m.p.h.
263	147 m.p.h.
264	111 m.p.h.
265	131½ m.p.h.
266	97½ m.p.h.
267	110 m.p.h.
268	141 m.p.h.
269	111 m.p.h.
270	182 m.p.h.
271	258 m.p.h.
272	164 m.p.h.
273	171 m.p.h.
274	139 m.p.h.
275	99½ m.p.h.
276	144½ m.p.h.
277	134 m.p.h.
278	190 m.p.h.
279	130 m.p.h.
280	175 m.p.h.
281	166 m.p.h.
282	152 m.p.h.
283	124 m.p.h.
284	130 m.p.h.
285	100½ m.p.h.
286	276 m.p.h.
287	159 m.p.h.
288	148 m.p.h.
289	190 m.p.h.
290	2 hours, 38 minutes;305 statute miles.
291	2 hours, 22 minutes, 30 seconds; 440 statute miles.
292	1h 48m; 162 n.m.
293	1h 25m; 210 n.m.
294	3h 54m; 506 n.m.
295	2h 58m; 362 n.m.
296	2h 40m; 266 s.m.
297	1h 28m; 246 s.m.
298	1h 20m; 173 n.m.
299	2h 34m; 429 n.m.
300	3h 08m; 689 s.m.
301	2h 13m; 298 s.m.
302	4h 47m; 320 s.m.
303	3h 33m; 419 s.m.
304	2h 15m; 425 s.m.
305	1h 54m; 304 n.m.

ANSWERS
EXAMPLES FOR PRACTICE

Problems
306..............2h 27m; 299 s.m.
307..............2h 53m; 1019 n.m.
308..............1h 24m; 232 n.m.
309..............1h 25m; 143 s.m.
310..............2h 04m; 254 n.m.
311..............1h 43m; 325 n.m.
312..............3h 05m; 446 s.m.
313..............2h 54m; 484 s.m.
314..............3h 54m; 475 n.m.
315..............2h 52m; 390 n.m.
316..............2h 58m; 1140 n.m.
317..............2h 41m; 325 s.m.
318..............2h 10m; 284 n.m.
319..............2h 03m; 217 n.m.
320..............2h 01m; 198 s.m.
321..............5h 04m; 608 s.m.
322..............1h 42m; 305 s.m.
323..............1h 22m; 205 s.m.
324..............2h 20m; 570 n.m.
325..............6h 36m; 376 s.m.
326..............160 degrees true course; 147 knots ground speed.
327..............29 degrees T.C.; 173 knots G.S.
328..............336 degrees T.C.; 149 knots G.S.
329..............142 degrees T.C.; 104 knots G.S.
330..............227 degrees T.C.; 148 knots G.S.
331..............122½ degrees T.C.; 118 knots G.S.
332..............189½ degrees T.C.; 225 knots G.S.
333..............118 degrees T.C.; 341 knots G.S.
334..............33 degrees T.C.; 100 knots G.S.
335..............99 degrees T.C.; 104 knots G.S.
336..............188 degrees T.C.; 167 knots G.S.
337..............353 degrees T.C.; 217 knots G.S.
338..............89 degrees T.C.; 129 knots G.S.
339..............112 degrees T.C.; 222 knots G.S.
340..............167 degrees T.C.; 150 knots G.S.
341..............162½ degrees true heading; 123 m.p.h. true airspeed.
342..............185 degrees T.H.; 221 m.p.h. T.A.S.
343..............242 degrees T.H.; 154 m.p.h. T.A.S.
344..............157 degrees T.H.; 109 m.p.h. T.A.S.
345..............350 degrees T.H.; 153½ m.p.h. T.A.S.
346..............000 degrees T.H.; 141 m.p.h. T.A.S.
347..............58 degrees T.H.; 150 m.p.h. T.A.S.
348..............316½ degrees T.H.; 123 m.p.h. T.A.S.
349..............116 degrees T.H.; 149 m.p.h. T.A.S.
350..............165½ degrees T.H.; 69 m.p.h. T.A.S.
351..............207 degrees T.H.; 200 m.p.h. T.A.S.
352..............122 degrees T.H.; 105½ m.p.h. T.A.S.
353..............265 degrees T.H.; 179 m.p.h. T.A.S.
354..............8½ degrees T.H.; 189 m.p.h. T.A.S.
355..............91 degrees T.H.; 160 m.p.h. T.A.S.
356..............163 degrees true heading; 112 m.p.h. ground speed.
357..............215 degrees T.H.; 211 m.p.h. G.S.
358..............169 degrees T.H.; 186 m.p.h. G.S.
359..............296 degrees T.H.; 354 m.p.h. G.S.
360..............16 degrees T.H.; 118½ m.p.h. G.S.
361..............31 degrees T.H.; 255 m.p.h. G.S.
362..............162 degrees T.H.; 146 m.p.h. G.S.
363..............132 degrees T.H.; 134 m.p.h. G.S.
364..............304 degrees T.H.; 138 m.p.h. G.S.

ANSWERS
EXAMPLES FOR PRACTICE

Problems
365.............205 degrees T.H.; 185 m.p.h. G.S.
366.............225 degrees T.H.; 142½ m.p.h. G.S.
367.............309 degrees T.H.; 220 m.p.h. G.S.
368.............299½ degrees T.H.; 232 m.p.h. G.S.
369.............115 degrees T.H.; 181 m.p.h. G.S.
370.............265 degrees T.H.; 374 m.p.h. G.S.
371.............Wind from 49 degrees at 10 m.p.h.
372.............3 degrees at 27 m.p.h.
373.............34 degrees at 20 m.p.h.
374.............208 degrees at 17 m.p.h.
375.............312 degrees at 40 m.p.h.
376.............None.
377.............338 degrees at 17 m.p.h.
378.............96 degrees at 28 m.p.h.
379.............91 degrees at 21 m.p.h.
380.............226 degrees at 10 m.p.h.
381.............194 degrees at 24 m.p.h.
382.............68 degrees at 13 m.p.h.
383.............98 degrees at 14 m.p.h.
384.............274 degrees at 27 m.p.h.
385.............191 degrees at 19 m.p.h.
386.............349 degrees at 29 knots.
387.............12 degrees at 35 knots.
388.............260 degrees at 12 knots.
389.............28 degrees at 31 knots.
390.............235 degrees at 47 knots.
391.............15 degrees at 26 knots.
392.............270 degrees at 26 knots.
393.............132 degrees at 22 knots.
394.............98 degrees at 33 knots.
395.............284 degrees at 6 knots.
396.............170 degrees at 35 knots.
397.............29 degrees at 32 knots.
398.............248 degrees at 27 knots.
399.............309 degrees at 54 knots.
400.............142 degrees at 36 knots.
401.............243 degrees at 23 knots.
402.............306 degrees at 30 knots.
403.............32 degrees at 18 knots.
404.............356 degrees at 37 knots.
405.............294 degrees at 27 knots.
406.............326 degrees at 32 knots.
407.............324 degrees at 21 knots.
408.............None.
409.............82 degrees at 8 knots.
410.............344 degrees at 52 knots.
411.............2 degrees at 30 m.p.h.
412.............313 degrees at 17 m.p.h.
413.............111 degrees at 33 m.p.h.
414.............177 degrees at 50 m.p.h.
415.............140 degrees at 20 m.p.h.
416.............342 degrees at 50 m.p.h.
417.............278 degrees at 10 m.p.h.
418.............261 degrees at 36 m.p.h.
419.............57 degrees at 16 m.p.h.
420.............327 degrees at 44 m.p.h.
421.............368
422.............9700
423.............314000

ANSWERS
EXAMPLES FOR PRACTICE

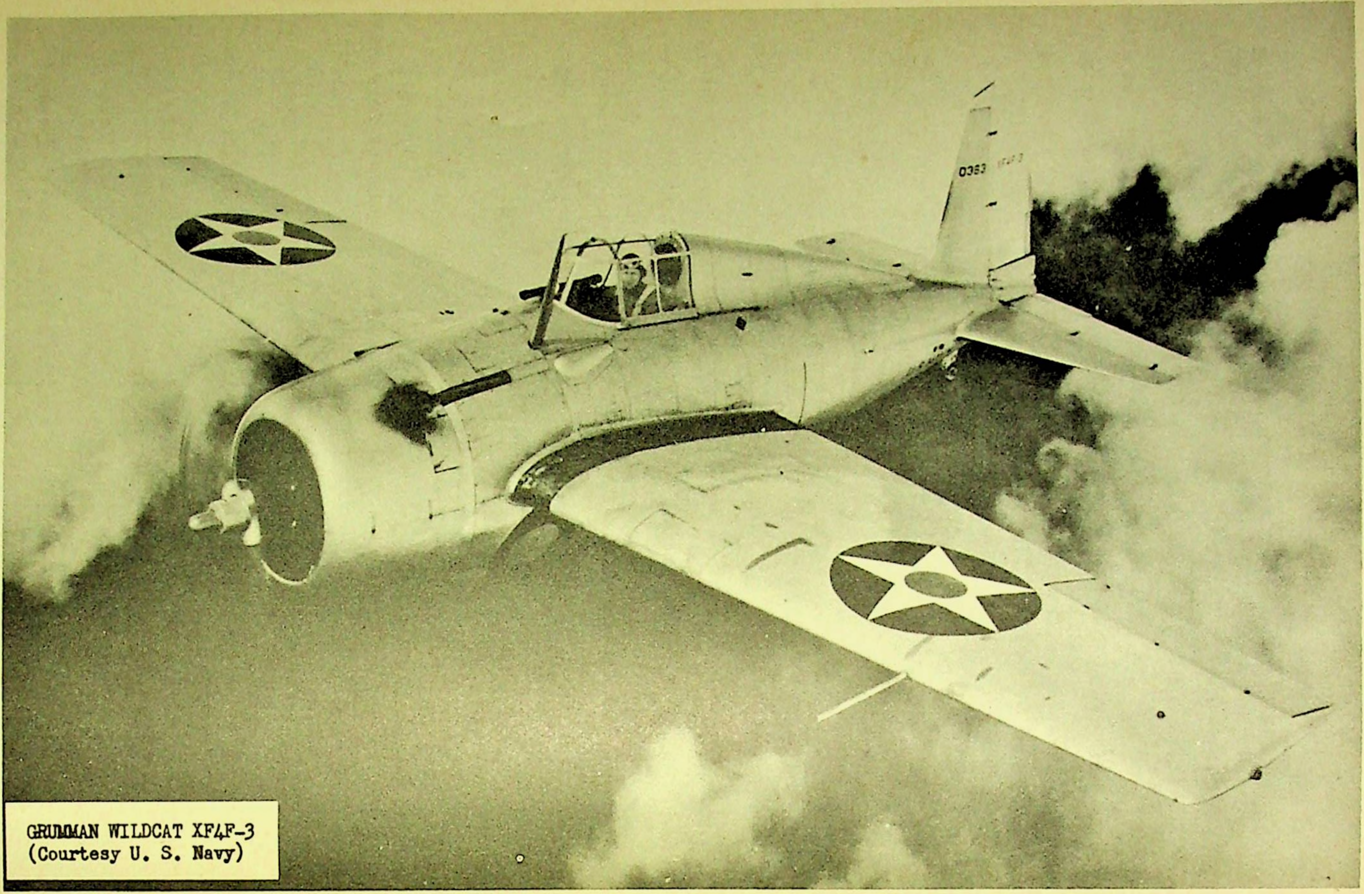
Problems	
424	2.79
425	0.347
426	2064
427	20.64
428	206.4
429	0.2064
430	2450
431	200
432	400
433	300
434	0.279
435	16
436	Wind from 42 degrees at 19 m.p.h. True heading "X" to "B" 175 degrees. Ground speed "X" to "B" 148 m.p.h. Time "X" to "B" 46 minutes.
437	Wind from 355 degrees at 32 m.p.h. True heading "X" to "B" 50 degrees. Ground speed "X" to "B" 169 m.p.h. Time "X" to "B" 1 hour 7 minutes.
438	Wind 229 degrees at 46 knots. True heading "X" to "B" 189½ degrees. Ground speed "X" to "B" 120 knots. Time "X" to "B" 50 minutes.
439	Wind 327 degrees at 19 m.p.h. True heading "X" to "B" 299 degrees. Ground speed "X" to "B" 119 m.p.h. Time "X" to "B" 1 hour 25 minutes 30 seconds.
440	Wind from 320 degrees at 55 knots. True heading "X" to "B" 309½ degrees. Ground speed "X" to "B" 101 knots. Time "X" to "B" 1 hour 29 minutes.
441	Wind 29 degrees at 28 m.p.h. True heading "X" to "B" 271 degrees. Ground speed "X" to "B" 153 m.p.h. Time "X" to "B" 59 minutes.
442	Wind 317 degrees at 40 knots. True heading "X" to "B" 360 degrees. Ground speed "X" to "B" 142 knots. Time "X" to "B" 1 hour 27 minutes 30 seconds.
443	Wind 290 degrees at 44 knots. True heading "X" to "B" 343 degrees. Ground speed "X" to "B" 158 knots. Time "X" to "B" 57½ minutes.
444	Wind 110 degrees at 18 m.p.h. True heading "X" to "B" 86 degrees. Ground speed "X" to "B" 94 m.p.h. Time "X" to "B" 1 hour 7 minutes.
445	Wind 352 degrees at 20 m.p.h. True heading "X" to "B" 20 degrees. Ground speed "X" to "B" 138 m.p.h. Time "X" to "B" 43 minutes.
446	273 degrees true heading "A" to "B". 130 m.p.h. ground speed "A" to "B". 136½ degrees true course "X" to "C". 136½ degrees true heading "X" to "C". 178 m.p.h. ground speed "X" to "C". 67 m.p.h. rate of departure. 212 m.p.h. rate of closure.

ANSWERS
EXAMPLES FOR PRACTICE

Problems	
446(continued)	592 miles radius of action.
	4 hours 33 minutes time "A" to "X".
447	159 degrees true heading "A" to "B".
	159 m.p.h. ground speed "A" to "B".
	317½ degrees true course "X" to "C".
	327 degrees true heading "X" to "C".
	172 m.p.h. ground speed "X" to "C".
	116 m.p.h. rate of departure.
	202 m.p.h. rate of closure.
	454 miles radius of action.
	2 hours 51 minutes time "A" to "X".
448	208 degrees true heading "A" to "X".
	191 knots ground speed "A" to "X".
	359 degrees true heading "X" to "C".
	202 knots ground speed "X" to "C".
	143 knots rate of departure.
	249 knots rate of closure.
	1099 nautical miles radius of action.
	5 hours 45 minutes time "A" to "X".
449	108 degrees true heading "A" to "X".
	150 m.p.h. ground speed "A" to "X".
	280½ degrees true course "X" to "C".
	183 m.p.h. ground speed "X" to "C".
	283½ miles distance "X" to "C".
	286 degrees true heading "X" to "C".
	227 m.p.h. rate of closure.
	103 m.p.h. rate of departure.
	517 miles raiuds of action.
	3 hours 27 minutes time "A" to "X".
450	90 degrees true heading "A" to "B".
	170 knots ground speed "A" to "B".
	358 degrees true heading "X" to "C".
	351 degrees true course "X" to "C".
	207 knots ground speed "X" to "C".
	26 minutes time "X" to "C".
	89½ nautical miles distance "X" to "C".
	603 nautical miles distance "X" to "C".
	3 hours 34 minutes time "A" to "X".
451	350 degrees true heading "A" to "B".
	143 m.p.h. ground speed "A" to "B".
	170 degrees true heading "X" to "C".
	175 degrees true course "X" to "C".
	272½ miles distance "X" to "C".
	174 m.p.h. ground speed "X" to "C".
	1 hour 34 minutes time "X" to "C".
	490 miles radius of action.
	3 hours 26 minutes time "A" to "X".
452	54 degrees true heading.
	62 degrees true course.
	165 knots ground speed.
	187 knots rate of closure.
	1 hour 6 minutes time to interception.
453	38 minutes time to interception.
	221½ degrees interception heading.
454	110 degrees true course.
	118 knots ground speed.
	3 hours 21 minutes time to interception.
455	92½ degrees true heading.
	27 minutes 30 seconds time to interception.

ANSWERS
EXAMPLES FOR PRACTICE

Problems
456.............159 degrees true heading.
59½ minutes time to interception.
457.............167 degrees true heading.
125 knots ground speed.
3 hours 15 minutes time to interception.



GRUMMAN WILDCAT XF4F-3
(Courtesy U. S. Navy)

NOMENCLATURE

AIR NAVIGATION...The art of determining the geographical position of an aircraft and maintaining a desired direction by means of pilotage, dead-reckoning, celestial, or radio navigation.

AIRSPEED...The speed of the aircraft relative to the mass of air through which it is flying.

Indicated airspeed...The speed of the aircraft as read from the airspeed indicator.

Calibrated airspeed...The indicated airspeed of the aircraft corrected for all instrument errors.

True airspeed...The calibrated airspeed of the aircraft corrected for temperature and pressure variation.

AIR TEMPERATURE...The temperature of the air at the altitude of the aircraft.

ALTIMETER...A navigation instrument which registers the altitude of the aircraft above a given datum plane.

ALTIMETER SETTING...Station pressure reduced to sea level pressure by taking into account the elevation of the station, the temperature, and the latitude. When used on the altimeter the plane lands with the instrument reading the elevation of the airfield.

ALTITUDE (of aircraft)...The height of an aircraft above some certain plane.

Indicated altitude...The height of the aircraft above sea level as read from the altimeter.

Calibrated altitude...The indicated altitude corrected for instrumental and installation errors.

Pressure altitude...The altitude of the aircraft above the standard datum plane. (29.92 inches of mercury at 15 degrees centigrade.)

True altitude...The altitude of the aircraft above sea level.

Absolute altitude...The altitude of the aircraft above the terrain it is flying over.

BEARING...The direction of one object from another expressed as a clockwise angle measured from true north.

CHART...A map used for the express purpose of navigation.

COURSE...The direction over the surface of the earth the aircraft is intended to be flown, expressed as a clockwise angle measured from true north. (True course.)

DEAD-RECKONING...The method of determining the geographical position of an aircraft by keeping an account of the track and ground speed with the aid of navigational instruments.

DEPARTURE, point of...A specified position from which a flight is commenced.

DISTANCE...The number of units of measurement between two points, usually expressed as statute or nautical miles.

DOUBLE DRIFT...A method of obtaining the wind direction and force by determining the drift angle on three predetermined headings.

DRIFT ANGLE...The angle between the heading and the track, expressed as right or left depending whether the wind is forcing the aircraft to the right or left of the heading.

NOMENCLATURE

ESTIMATED TIME OF ARRIVAL (ETA)...The computed time that an aircraft will reach its destination.

GREAT CIRCLE...A circle on the surface of the earth, formed by a plane passing through the center of the earth. The shortest distance between any two points on the surface of the earth, will always be along a great circle.

GROUND SPEED...The speed of the aircraft relative to the surface of the earth.

GROMMET...The name applied to the small black circle in the center of the face of the E-6B computer.

HEADING...The angular direction of the longitudinal axis of the aircraft, measured as a clockwise angle from true north. It is obtained by applying the wind correction angle to the intended true course.

INTERCEPT BEARING...The bearing that an aircraft must maintain to intercept a moving object.

INTERCEPT HEADING...The heading of the aircraft necessary to maintain a given course to intercept.

NAUTICAL MILE...A unit derived to measure distance along any great circle. 1 minute along any great circle equals 1 nautical mile.

LATITUDE...The angular distance, of a position, north or south of the earth's equator.

LONGITUDE...The angular distance, measured at the pole, east or west of the Greenwich meridian to the meridian passing through the position.

LUBBER'S LINE...A line on an aircraft instrument used to indicate the fore and aft or longitudinal axis. This line furnishes a reference line on the compass to obtain heading.

MERCATOR COURSE...On the Mercator chart any straight line will be a Rhumb line, or Mercator course.

NO WIND POSITION...A theoretical position at which the aircraft would be if there was no wind.

OFF COURSE CORRECTION...A correction applied to the heading to parallel or return to the original course.

PILOTAGE...Maintaining the desired direction and speed of an aircraft by visual reference to landmarks on the terrain below.

POINT OF INTERCEPTION...The geographical position at which interception takes place.

RADIUS OF ACTION...The distance an aircraft can fly out from a base, under known conditions of fuel consumption, wind and airspeed, and still proceed to an alternate base or back to the departure point.

RELATIVE BEARING...The direction of an object, measured clockwise from the longitudinal axis of the plane, to the line passing through the object.

RELATIVE MOTION...The motion of the aircraft relative to the motion of

NOMENCLATURE

another object.

RELATIVE WIND...The force and direction of the wind with respect to any moving object.

RHUMB LINE...A line on the surface of the earth that cuts all meridians at the same angle.

TRACK...The actual path of the aircraft over the surface of the earth.

TRUE COURSE...The intended track of the plane.

VARIATION...A compass error occasioned by the different position of the true and magnetic north poles.

WIND CORRECTION ANGLE...The angle between the heading and the course of the plane. Applied to the true course it gives the heading necessary to make good the course.

WIND DIRECTION AND FORCE...The wind is designated as the direction from which it blows, in miles per hour or knots.

WIND STAR...The small triangle on the computer resulting from the intersection of the drift lines, in the solution of the double drift problem.

APPENDIX

TABLE I, EQUIVALENTS

Linear Equivalents

1 centimeter	equals	10.0 millimeters
		0.3937 inches
1 meter	equals	1,000 millimeters
		100 centimeters
		39.37 inches
		3.28083 feet
		1.09361 yards
1 kilometer	equals	1,000 meters
		0.53959 nautical miles
		0.62137 statute miles
		1,093.61 yards
		3,280.83 feet
1 inch	equals	2.54001 centimeters
		25.4001 millimeters
1 foot	equals	12 inches
		0.3048 meters
		30.4801 centimeters
1 yard	equals	3.0 feet
		36.0 inches
		0.000568 statute miles
		0.000493 nautical miles
		0.91440 kilometers
1 statute mile	equals	5,280 feet
		1,760 yards
		0.8683 nautical miles
		1.60935 kilometer
1 nautical mile	equals	6,080.20 feet
		2,027.0 yards
		1.15155 statute mile
		1.85325 kilometer

Time Equivalents

1 hour	equals	60 minutes
		3,600 seconds

From Greenwich Civil Time-

To obtain Eastern Standard Time subtract 5 hours.
To obtain Central Standard Time subtract 6 hours.
To obtain Mountain Standard Time subtract 7 hours.
To obtain Pacific Standard Time subtract 8 hours.

Power Equivalents

1 horsepower	equals	33,000 footpounds per minute
		550 footpounds per second
		745.7 watts
1 watt	equals	1 ampere volt

Pressure Equivalents

1 inch of mercury	equals	2.54 centimeters of mercury
		0.4912 pound per square inch
		33.864 millibars
1 millibar	equals	0.02953 inch of mercury
		0.0145 pounds per square inch

Temperature scales

To change Farenheit to Centigrade:

Centigrade equals 5/9 (Farenheit minus 32)

APPENDIX

TABLE I, EQUIVALENTS

Temperature scales (continued)
To change Centigrade to Farenheit:

Farenheit equals (9/5 Centigrade) plus 32

TABLE II, TEMPERATURE CONVERSIONS

Centigrade	Farenheit	Centigrade	Farenheit
-10	14.0	15	59.0
- 9	15.8	16	60.8
- 8	17.6	17	62.6
- 7	19.4	18	64.4
- 6	21.2	19	66.2
- 5	23.0	20	68.0
- 4	24.8	21	69.8
- 3	26.6	22	71.6
- 2	28.4	23	73.4
- 1	30.2	24	75.2
0	32.0	25	77.0
1	33.8	26	78.8
2	35.6	27	80.6
3	37.4	28	82.4
4	39.2	29	84.2
5	41.0	30	86.0
6	42.8	31	87.8
7	44.6	32	89.6
8	46.4	33	91.4
9	48.2	34	93.2
10	50.0	35	95.0
11	51.8	36	96.8
12	53.6	37	98.6
13	55.4	38	100.4
14	57.2	39	102.2

TABLE III, GROUND SPEED BY TIMING

FACTORS FOR GROUND SPEED BY TIMING

$$\frac{\text{NAUTICAL MILES}}{\text{HOUR}} = \frac{\text{ALTITUDE (FEET)}}{\text{TIME (SECONDS)}} \times \text{FACTOR}$$

START / FINISH	* 0°	10°	20°	30°	40°	50°
5°	.052					
10°	.104					
15°	.159	.054				
20°	.216	.111				
25°	.276	.172	.061			
30°	.342	.238	.126			
35°	.415	.310	.199	.073		
40°	.497	.392	.281	.155		
45°	.592	.488	.377	.250	.095	
* 50°	.706	.601	.490	.364	.209	
55°	.846	.741	.630	.504	.349	.140
60°	1.026	.922	.810	.684	.529	.320
65°	1.270	1.165	1.054	.928	.773	.564
* 70.9°	1.706	1.602	1.490	1.364	1.209	1.000

* B-3 DRIFTMETER HAS DETENTS AT THESE ANGLES.

Nautical miles per hour

FACTORS FOR GROUND SPEED BY TIMING

$$\frac{\text{STATUTE MILES}}{\text{HOUR}} = \frac{\text{ALTITUDE (FEET)}}{\text{TIME (SECONDS)}} \times \text{FACTOR}$$

START / FINISH	* 0°	10°	20°	30°	40°	50°
5°	.0596					
10°	.1202					
15°	.1827	.0625				
20°	.2482	.1280				
25°	.3179	.1977	.0697			
30°	.3937	.2735	.1455			
35°	.4774	.3572	.2292	.0837		
40°	.5721	.4519	.3239	.1784		
45°	.6818	.5616	.4336	.2881	.1097	
*50°	.8126	.6924	.5644	.4189	.2405	
55°	.9737	.8535	.7255	.5800	.4016	.161
60°	1.181	1.062	.9328	.7873	.6088	.369
65°	1.462	1.342	1.214	1.068.	.8900	.650
*70.9°	1.9	1.846	1.716	1.571	1.393	1.152

* B-3 DRIFTMETER HAS DETENTS AT THESE ANGLES

Statute miles per hour

ABBREVIATIONS

A	Designation of departure
AA	Absolute altitude
Alt	Altitude
AP	Airport
AS	Air Speed
B	Designation of destination
Bn	Beacon
C	Designation of Alternate
CA	Calibrated altitude
CAR	Civil air regulations
CAS	Calibrated air speed
CC	Compass course
CH	Compass heading
CN	Compass north
Corr	Correction
D	Drift
DA	Drift Angle
DD	Double Drift
D/F	Direction Finding
DR	Dead Reckoning
Dev	Deviation
ET	Estimated Time
ETA	Estimated time of arrival
ETE	Estimated time elapsed
G	Greenwich
GCT	Greenwich civil time
GS	Ground speed
IA	Indicated altitude
IAS	Indicated air speed
K	Knot
Kts	Knots
Lat	Latitude
Long	Longitude
Mb	Millibar
MC	Magnetic course
MH	Magnetic heading
MN	Magnetic north
MPH	Miles per hour
nm.	Nautical miles
O	Origin
PA	Pressure altitude
pos	Position
R/A	Radius of action
RB	Relative bearing
RW	Relative wind
S1	Rate of departure
S2	Rate of closure
sm.	Statute miles
STD	Standard datum plane
TA	True altitude
TAS	True air speed
TB	True bearing
TC	True course
Temp	Temperature
TH	True heading
TN	True north
Var	Variation
W	Wind
W/d	Wind direction
W/f	Wind force
WCA	Wind correction angle
X	Off course or turn position

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